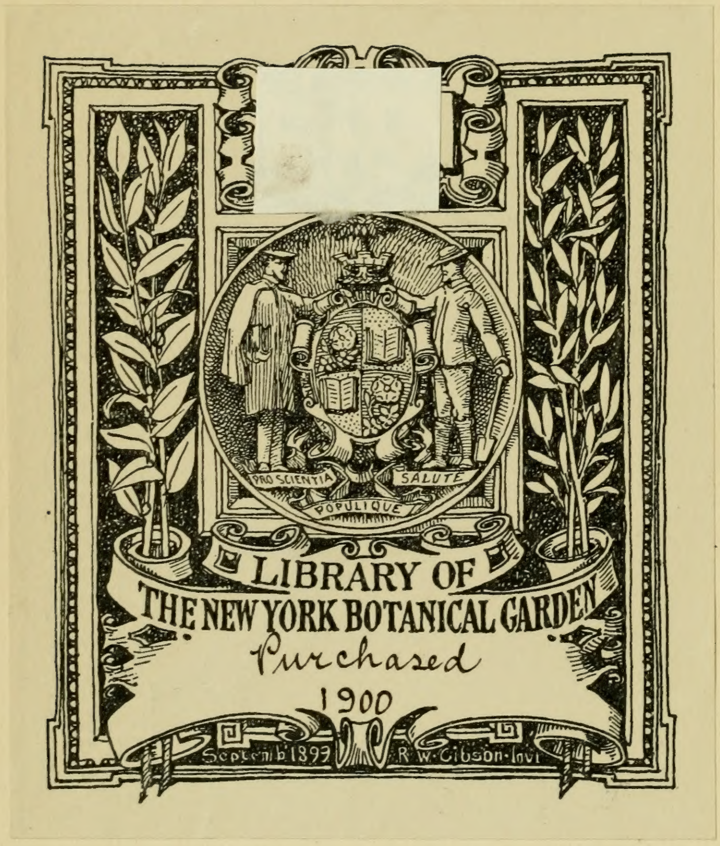
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LETTER

FROM THE

SECRETARY OF THE TREASURY,

TRANSMITTING THE

Information required by a resolution of the House of Representatives, of May 11, 1826,

IN RELATION TO THE

GROWTH AND MANUFACTURE OF SILK,

ADAPTED TO THE DIFFERENT PARTS OF THE UNION.

by Richard Rush

FEBRUARY 7, 1828.

Communicated to the House of Representatives—Referred to the Committee on Agriculture, of that House.

APRIL 21, 1828.

Printed by order of the Senate of the United States.

WASHINGTON:

PRINTED BY DUFF GREEN.

1828.

IN SENATE OF THE UNITED STATES.

April 21, 1828.

Resolved, That 2000 copies of the reports of the Secretary of the Treasury, communicated to the House of Representatives at the present session of Congress, relative to the culture of the White Mulberry tree and the manufacture of Silk, be printed for the use of the Senate.

TREASURY DEPARTMENT,
February 5, 1828.

SIR: In obedience to a resolution of the House of Representatives, passed on the eleventh of May, 1826, directing that "the Secretary of the Treasury cause to be prepared a well-digested Manual, containing the best practical information that can be collected on the growth and manufacture of silk, adapted to the different parts of the Union, and containing such facts and observations, in relation to the growth and manufacture of silk in other countries, as may be useful," I have the honor to transmit to the House the accompanying report.

This report, by an additional clause of the resolution, ought to have been made at the session immediately succeeding that at which the resolution passed; but the interval was found to be too short to render this practicable. In order to procure the materials from which alone the Manual could be adequately prepared, it became necessary to institute a correspondence co-extensive with the Union, and to seek additional light in relation to the subject from several countries abroad. The returns to inquiries thus instituted by the Department, had not even been received, except in part, during the interval above-mentioned, although no time had been lost in instituting them. The work has since proceeded with as much expedition as was believed to comport with the care due to its preparation; which, amongst other things, included plates, for the better illustration of some parts of the machinery used in manufacturing silk. These explanations, it is hoped, may be received as satisfactory.

I have the honor to remain,
With high consideration and respect,
Your obedient servant,
RICHARD RUSH.

The Honorable the SPEAKER
of the House of Representatives U. S.

HOUSE OF REPRESENTATIVES,
December 29, 1825.

On motion of Mr. MINER,

Resolved, That the Committee on Agriculture be instructed to inquire whether the cultivation of the mulberry tree, and the breeding of silk worms, for the purpose of producing silk, be a subject worthy of legislative attention; and should they think it to be so, that they obtain such information as may be in their power, respecting the kind of mulberry tree most preferred, the best soil, climate, and mode of cultivation, the probable value of the culture, taking into view the capital employed, the labor, and the product, together with such facts and opinions as they may think useful and proper.

Resolved, That the same Committee inquire whether any Legislative provisions are necessary or proper to promote the production of silk.

HOUSE OF REPRESENTATIVES,
May 2, 1826.

Mr. VAN RENSSELAER, from the Committee on Agriculture, to which the subject had been referred, made the following

REPORT:

The Committee on Agriculture, to whom was referred the resolution of Mr. MINER, to inquire whether the cultivation of the mulberry tree and the breeding of silkworms, for the purpose of producing silk, be a subject worthy of legislative attention; and should they think it to be so, that they obtain such information as may be in their power respecting the kind of mulberry most preferred, the best soil, climate, and mode of cultivation, the probable value of the culture, taking into view the capital employed, the labor, and the product, together with such facts and opinions as they may think useful and proper;

REPORT:

That they have examined the subject attentively, and have taken such steps as they thought best calculated to obtain information which might be useful and lead to satisfactory conclusions.

The facts developed in the course of their inquiries, tend to place the subject in an important point of view. It is an interesting fact, that the mulberry tree grows indigenously throughout the United States, and that silk may be raised with facility from the Southern to the Northern boundary of the Union. Formerly, considerable quantities of silk were produced in Georgia. In 1760 more than twenty thousand pounds of cocoons were exported from thence to England. The produc-

tion of the article was suspended, not from any difficulty experienced in the process, but from causes connected with the Revolution. Measures have recently been adopted at Savannah, with a view to the renewal of the cultivation of the mulberry tree and breeding the silkworm. In Kentucky, the Committee learn that sewing silk is now produced in considerable quantities, and of excellent quality. Many years ago the attention of public spirited individuals in Pennsylvania was turned to the production of silk. The Persian mulberry was introduced into Bethlehem, Pennsylvania, by Bishop Ettwein, where it flourished and still flourishes. Silk was produced without difficulty. In Chester and other of the southern counties of that State, the experiment was also made with success. The great demand and high price of bread stuffs, owing to the wars growing out of the French revolution, rendered the cultivation of grain so profitable for many years, that the mulberry was neglected. In 1779 two hundred pounds of sewing silk were made in the town of Mansfield, in Connecticut; and in 1810, according to the report of the marshal who took the census, the value of silk produced in Windham county was estimated at $27,373. The Committee learn that the production of silk is still attended to and found profitable. Some beautiful specimens of sewing silk, the production of that State, have been exhibited to the Committee. Of the fact, therefore, that the United States can produce silk for its own consumption, and even for exportation to the extent of foreign demand, there appears no reason to doubt. There are few persons, the Committee believe, even the most intelligent of our citizens, (who have not turned their attention particularly to the subject,) who will not be surprised at the view presented by the following official statement of the value of silks imported into the United States the last five years:

Statement of the value of silk goods imported and exported in the years 1821 *to* 1825, *inclusive.*

Years.	Imported.	Exported.
1821	$4,486,924	$1,057,233
1822	6,480,928	1,016,262
1823	6,713,771	1,512,449
1824	7,203,344	1,816,325
1825	10,271,527	2,565,742
	$35,156,494	$7,968,011

What a bounty is paid by us to support the agriculturist and manufacturer of other nations, on articles which our country, with a few years of care, might supply! How important it is that the agriculturist should turn his attention to new objects of production, is very fully shown by the circumstance of the diminished and diminishing demand of bread stuffs abroad.

In 1817, the exports of bread stuffs amounted to	$20,374,000
In 1818,	15,388,000
In 1824,	6,799,246
In 1825,	5,417,997

An importation of ten millions of dollars of silk—an export of five millions of bread stuffs! The facts speak the importance of the subject, and indicate the necessity that exists of awakening the slumbering agricultural resources of our country, by introducing new and profitable articles of production. Knowledge is power, in agriculture, no less than in politics; information is capital, and the means of valuable improvement. The Committee conceive that the first and most important measure to be taken, is to acquire and circulate clear, distinct, and precise information on these points: the relative value of the cultivation of the mulberry, and the production of silk, compared with other agricultural productions in the different sections of the Union, capital and labor being considered. The kind of mulberry best suited to the object; the most advantageous mode of cultivation; the most approved manner of managing the silkworm, and an explanation of the process till the article is ready for market. The Committee incline to the opinion that the best mode of raising silk will be for every farmer and planter to appropriate a small portion of ground, as for a fruit orchard, for raising the mulberry tree, calculating to produce as many worms as his own family will enable him to manage without increasing his expenses, and without permitting it, until the experiment shall have been fully tried, to interfere with the regular course of his usual pursuits. A single acre planted with the mulberry will produce from 500 to 600 pounds raw silk, the value of which to the individual would richly compensate for the capital and labor employed, and the aggregate to the country be of great importance.

The fact is worthy of notice, that, notwithstanding the high price of land in Ireland, where a year's rent of land exceeds the price of the soil in many parts of our country, yet so valuable is the mulberry considered, that importations of trees from the Mediterranean have been made during the last year, for the purpose of producing silk. Your Committee addressed inquiries to several intelligent gentlemen who were presumed competent to give them information upon the subject; and among the papers received in reply, they beg leave to present to the particular attention of the House a valuable memoir, replete with interesting facts and useful information, from Edmund C. Genet, Esq. and also several communications from other gentlemen, to whose attention the Committee acknowledge their obligations. As the result of these inquiries, believing that knowledge on the subject is of the first importance, the Committee submit the following resolution:

Resolved, That the Secretary of the Treasury cause to be prepared a well-digested Manual, containing the best practical information that can be collected on the growth and manufacture of silk, adapted to the different parts of the Union, containing such facts and observations in relation to the growth and manufacture of silk, in other countries, as may be useful, and that the same be laid before Congress at the commencement of their next session.

HOUSE OF REPRESENTATIVES,
FEBRUARY 11, 1828.

Mr. VAN RENSSELAER, from the Committee on Agriculture, to which the subject had been referred, made the following

REPORT:

The Committee on Agriculture, to which was referred the report of the Secretary of the Treasury, made in pursuance of a resolution of the House of Representatives, passed the eleventh of May, 1826, directing the Secretary to prepare a well-digested Manual on the growth and manufacture of silk, have agreed to the following resolution, which they have instructed their Chairman to submit to the House:

Resolved, That six thousand copies of said Manual and Report be printed for the use of the House.

A MANUAL

ON THE CULTURE OF SILK, AND ITS MANUFACTURE,

Prepared under the instructions and superintendence of the Secretary of the Treasury, in compliance with a resolution of the House of Representatives of the United States, introduced by the Honorable Charles Miner, of Pennsylvania, and adopted on the eleventh of May, 1826, in the following words, viz:

Resolved, That the Secretary of the Treasury cause to be prepared a well-digested Manual, containing the best practical information that can be collected, on the growth and manufacture of silk, adapted to the different parts of the Union, containing such facts and observations, in relation to the growth and manufacture of silk in other countries, as may be useful, and that the same be laid before Congress at the commencement of their next session.

The following queries were propounded by the Secretary of the Treasury, to the various persons in the United States, to whom a copy of the Resolution of the House of Representatives was transmitted.

1. What efforts have been made in the State of ———, if any, and at what periods of time, to raise silk?

2. Whence was the silkworm obtained? Is this insect a native of ———, and, if so, in what respects does it differ, if any, from the oriental or foreign silkworm? Are there any varieties of this insect known in ——— ? Please to describe whatever kinds there may be.

3. Does the mulberry flourish in ———, in its different varieties; what soil suits it best; is the white mulberry an indigenous tree? If not, has it been found to thrive as well in the United States as the red and black mulberry? Which of the latter is indigenous, or are both?

4. Does the silkworm feed as well upon the red and black mulberry as upon the white? Is there any other leaf or plant known in this country upon which it does feed; and, above all, will it yield silk of equal quality when fed upon any other leaf or food, as upon that of the white mulberry?

5. Be pleased to state the best methods of raising and multiplying the several species of the mulberry tree; how it is propagated; how old it should be before transplanting; what particular modes of treating it are required; the age at which it should begin to furnish food for the worm; whence trees or cuttings can be obtained for transplantation; the price per hundred; how many trees should be planted on an acre: and would it, or would it not, be profitable to cultivate the mulberry, for the purpose of feeding the worm, in the form of a bush or shrub?

6. What quantity of raw silk ought to be produced from an acre of full-grown mulberry trees, planted and reared in the best manner? How many silkworms are required to produce a pound of raw silk? What quantity of raw silk can be produced from an acre of mulberry-trees, by other modes of cultivation than the full-grown tree?

7. Be pleased to state, as much in detail as may be in your power, the methods of treating the silkworm, with a view to raising the best silk, and in the greatest quantity; embracing, particularly, the habits of the insect, as to appetite, cleanliness, position, or accommodations, whilst the cocoon is forming; the species of twig or branch on which it is best that it should be spun; temperature, and degree of light most favorable to the insect; and all other circumstances which may affect its health and strength, and its capacity to yield a perfect cocoon; also, a description of the process of forming the silk by the insect until the cocoon is completed; the best modes of treating the cocoon, and of obtaining the silk; and how far the labor of females, children, and old men, may be usefully employed in the culture of silk?

8. What difference, if any, exists between the Chinese and Italian or Spanish worm; which country is reputed to produce the best insect, and what particular part of the country?

9. Does the climate of ——— admit of raising silk with full advantage in the open air; or is it best that the insect should always be housed?

If the latter, what size and form of building or apartment is best fitted to its operations? If the silk be raised in the open air, is any shelter, and of what kind required, as well from the rays of the sun as from wet, and to protect the insects from birds and other animals that prey upon them?

10. Is there reason to suppose that, in some parts of the United States, the climate may admit of more than one crop of silk being raised from the silkworm, in the course of the year, as in Asia? How will this inquiry apply to ——— ?

11. Have lightning and thunder been found to affect the silkworm in our climate, and how far, if at all? Has any insect of our climate, or animal of any kind, been found to prey upon, or injure it, beyond those that are known to do so in other climates?

12. What is the greatest quantity of silk that has been raised in the State of ———, in any one year; into what articles or forms has it been manufactured; and have the manufactured articles been consumed at home or sent abroad, and where; where has the raw silk been sent when not wrought into manufactures?

13. What prices have the raw or manufactured silks commanded in the market of the United States, as compared with similar articles imported from Europe, China, or the East Indies? What progress has been made in the drawing, spinning, and twisting of sewing silk in any part of ———? Have its strength and evenness been equal to the French, English, or Italian sewing silk? How have we succeeded in the coloring or dying? All information on this head will be acceptable.

14. Will you be pleased to describe, with as much particularity as may be, the machinery most approved for winding off the silk from the cocoon; for forming it into organzine or thrown silk; and for manufacturing silk into all its different forms, (including velvets,) whether for clothing, furniture, or any other purpose? If within your power and convenience to add a sketch or drawing, of any or all of the above machinery, it would be acceptable.

17. Describe the difference in the quality of the silk produced from all the different varieties of the silkworm, and annex, if in your power, a drawing (colored) of all the varieties of this insect, in its moth and other states. Is the insect brought from abroad supposed to degenerate in the United States, and if so, to what causes is it imputed, and how are they best to be obviated? What are the proper rules to be observed in the choice of eggs, in the choice of cocoons for seed, and in the choice of the insect for laying eggs?

16. If silk has been raised at any periods heretofore in ———, but not at present, what are supposed to be the causes that have led to its discontinuance?

17. Please to state any other facts or circumstances that may bear upon the objects or spirit of the resolution above referred to, of the House of Representatives of the United States, though not specially comprehended under any of the foregoing inquiries.

RICHARD RUSH.

TREASURY DEPARTMENT, *29th July*, 1826.

PREFACE.

In considering the subject of the culture of silk, it was the first intention of the writer of this Manual to compose an entire treatise in his own language; and some progress in the collection of materials for it was made; when, upon a careful perusal of the work by Count Dandolo, of Italy, it was found to embrace every part of the art of rearing silkworms, so much more fully than any of the numerous treatises, in English or French, which the writer had read, and exhibited, throughout, such marks of method, so much pains, intelligence, and attention, such scrupulous accuracy, in all his proceedings and directions, that it was deemed most adviseable to make it the basis of the intended Manual. The author wrote from ample experience in the art upon which he undertook to instruct others; and it appears from a late traveller,* and writers on silkworms, that his plan for their treatment has generally been substituted for those formerly adopted in Italy and France. Dandolo's work has, therefore, been carefully abridged; a measure rendered necessary from its diffuse nature, and the many details and particulars of minute inquiries into circumstances connected with the silk culture given therein, but which do not lead to any profitable result. These are omitted, and nothing inserted but that which is purely practical. Having the use of the original work in Italian, and the French translation, from which the English version was made, the errors of the latter were corrected.

The directions and plans of this experienced author, refer to a large establishment of five ounces of eggs, but the intelligent cultivator will readily apply them to a scale of any size; in all cases, the practical results will be similar.

To the directions and observations of Dandolo, many others are added, which were derived from an extensive correspondence instituted by the Secretary of the Treasury, in all parts of the Union, on the subject matter of the resolution of the House of Representatives, as well as from information taken from the most valuable and recent publications obtained by the Secretary, from different parts of Europe. To these abundant sources of knowledge, were added others, which the writer himself was able to command; among these was a free access, during the past year, to a large establishment, conducted upon the plan pointed out by Count Dandolo. To the practical part are prefixed a short history of silk in ancient times; an account of the former and present state of its culture in North America: and the natural history of the silkworm.

* Mr. J. Murray—Treatise on Silkworms, Edinburgh, 1826.

On the subject of the manufacture of silk, all the information has been given which it was possible to obtain from books and other sources. It is now known, that very great improvements in the machinery for the preparation of the raw material, have been recently made; but an account of some of them could not be obtained sufficiently definite to authorize their insertion. Fanshaw's improvement,* of which a copy has been taken from a recent English publication, is spoken of in the highest terms by "the trade." To this are added, plates and descriptions of a new tramming machine, and of two looms, both of which received premiums from the London Society for the Encouragement of Arts: one of them shows the improvements it contains, in connexion with the whole apparatus for weaving silk, as now employed in Spitalfields. The whole machinery for the manufacture of silk, is given in the French Encyclopædia, published at the commencement and during the early part of their revolution, and is contained in one hundred and thirty-one quarto plates, and upwards of four hundred figures, some of which occupy a whole page: the letter press fills one hundred and seventy-two pages. Much of this machinery is now laid aside for others of a more simple nature; but the work may still be consulted with advantage by those who intend to engage in the business, from the minute accuracy of the figures of those parts which are still retained. It would have been impossible to copy these plates; and even the insertion of all the recent patents and improvements would have been inconsistent with the object of this Manual. They have, therefore, in part, been omitted, and references made to them, which manufacturers may find it their interest to consult.

The subject of dying silk, although not expressly mentioned, was nevertheless considered as included in the spirit of the resolution of the House of Representatives. Accordingly, directions to prepare the raw material for various tints, and observations connected with the art, with receipts for different colors, have been given. It is hoped they will be found useful, as great pains were taken to collect and select them from the latest and most approved writers. Care has been taken to avoid repeating what has been said by Dr. Cooper, in his treatise on dying, as that work is to be easily procured.

Upon the whole, the compiler can truly say, that he has endeavored to accomplish the task with which he has been charged, to the best of his abilities, and with all the zeal which a firm conviction of the importance of the silk culture could inspire.

* For spinning, doubling, and twisting, or throwing silk. London Journal of Arts and Sciences, for July, 1827.

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INTRODUCTION.

HISTORY OF SILK.

The silkworm, or, more properly, the silk-caterpillar, is a native of China. The people resident in the northern part of that country, called Seres, having been expelled by the Huns, in the ninety-third year of the Christian era, settled in Little Bucharia,* and were, for many centuries, the sole cultivators of the precious article, with which they supplied the rest of the world. The earliest mention of silk is in the translation of the Bible by Jerome, who enumerates it among the numerous articles which were imported from Syria by the Phœnicians, those spirited merchants and skilful manufacturers, who, although seated in a barren and narrow country, confined on one side by the sea, and by a range of mountains on the other, became a great naval and commercial power, which, for a very long period, rendered their "merchants princes, and their traffickers the honorable of the earth."† The singular lustre and beauty of silk, and the delicate structure of the fabric, could not fail to prove highly attractive to mankind: and hence it constituted one of the articles which were brought from China by traders, who, in caravans, performed long and toilsome journeys through the trackless sands and deserts of Asia, to the different ports of Syria and Egypt, which successively became the depôts of commerce. For a long time, two hundred and forty-three days were consumed in these expeditions. Cosmas, himself a trader, speaks of the distance between China and Persia, as requiring one hundred and fifty days to perform the route. The cities of Turfan and Cashgar, were the rendezvous of these caravans.‡

The Seres themselves never left home, being "a gentle race who shunned mankind."

The distance whence the article was brought, and the small quantities with which the world was supplied, necessarily caused the price to be far beyond the reach of any but the rich; and even when the Roman power extended over half the globe, as then known, this brilliant and ornamental article of dress was scarcely known to them. It is probable, that they first became acquainted with its real nature from the writings of Dionysius Periegetes, the geographer, who had

* The identity of Bucharia with the country of the Seres, is established from the description of it by Ammianus Marcellinus, a writer of credit in the third century.

† Isaiah xxiii. 8.

‡ Ptolemy speaks of Comedæ, (the present Cashgar,) as the "receptaculum eorum qui ad Seres negotii causa profisciuntur, penes Imaum Montis." Asia, tab. vii.

been sent by Augustus to compile an account of the oriental regions, and who informed his countrymen that precious garments were manufactured by the Seres, from threads finer than those of the spider.* Among all the articles of elegance belonging to the luxurious Cleopatra, none seemed to excite their admiration and astonishment, as the silk sails of her pleasure-barge, in which she visited them at Alexandria. For a long time after, it continued to be so scarce and dear, that, in the Roman dominions, it was confined to women of fortune. It was, moreover, deemed so effeminate an article, as to be unfit for the dress of men; and, in the reign of Tiberius, a law was passed, "that no man should dishonor himself by wearing silken garments."† Two hundred years subsequent to this date, the use of it constituted one of the many opprobrious charges which were made against the character of the emperor Elagabulus. Even fifty years after, another emperor‡ refused his queen a garment of silk, by reason of the high price it bore —its weight in gold.

For centuries, the Persians enjoyed a monopoly of the trade in silk; but, after they were subdued by Alexander, (300 years before Christ,) this valuable commodity was brought to Greece, and thence sent to Rome. The anxiety of the luxurious people of that nation, to trade with those from which the costly article was to be procured, induced the Emperor Marcus Antoninus to send ambassadors to negotiate a more direct commercial intercourse with their country, than the subjects of Rome had yet been able to accomplish; and, as the jealousy of the Parthians and Persians prevented the passage of all foreigners through their kingdoms to China, the ambassadors were obliged to proceed by the tedious way of Egypt and India. Another was sent in the year 272, which led to more favorable arrangements, and a shorter route, viz: along the ranges of mountains, now called Hindookho, and Cuttore.§ But the price of silk, for a long time, continued a source of regret, and the article an object of increasing desire among the wealthy. Justinian made another attempt, shortly after he ascended the throne, to obtain it. He sent Julian as his ambassador to the Christian king of Axuma, in Abyssinia, requesting that, for the sake of their common religion, he would assist him in a war with Persia, and direct his subjects to purchase silks in India, in order to sell them to the Romans, whereby the Axumites would acquire great wealth, and the Romans would have the satisfaction of paying their gold into the hands of their friends, instead of enriching their Persian enemies. Julian also urged the Homerites in Arabia Felix, then under the vassalage of Axuma, to the same effect; and promised, on the part of the emperor, to purchase silk from them, if, with their assistance, he could wrest the silk trade from the Persians, and they become the medium of intercourse with the country of the Seres. The kings of both the countries promised to comply with the emperor's

* Periegetes de situ orbis, 6 v. p. 752.

† Ne Vestis Serica viros fœdaret. Tacitus, book 2d, chap. 33.

‡ Aurelian. Vopiscus in vitam Aureliani, c. 45, libra enim auri tunc libra serici fuit.

§ See Rennel's map of the countries between the Ganges and the Caspian Sea.

request; but neither were able or willing to fulfil their engagements. The alleged causes for their non-compliance, were some internal commotions among the Homerites, and the recall of Belisarius, who, with an army, to which the Arabian auxiliary troops were joined, protected the East from the invasions of the Persians.* This nation, by having the command of the land carriage from the country of the Seres, still enjoyed almost an exclusive trade with respect to the western world, in Indian commodities, but more especially silk, with which it supplied remote nations at extravagant prices. From this distress, which was felt and lamented as a real misfortune by the Senators of the Roman empire, they were released in a very extraordinary and unexpected manner. The preachers of the Nestorian doctrine, having been exiled by the persecuting spirit of the ecclesiastical government of Byzantium, fled to India. Their patriarch, who resided in Persia, sent missions, and every where established convents and bishoprics. Two of his monks, who had been employed as missionaries in some of the Christian churches, which were established in different parts of India, having penetrated into the country of the Seres, had observed the labors of the silkworms, and become acquainted with the art of working their production into a variety of elegant fabrics. Aware of the anxiety of the Europeans on this subject, they repaired to Constantinople, and imparted to the emperor Justinian, the secret which had hitherto been so well preserved by the Seres, that silk was produced by a species of worms, the eggs of which might be transported with safety, and propagated in his dominions. By the promise of a great reward, they were induced to return, and brought away a quantity of the silkworm's eggs, in the hollow of a cane, and conveyed them safely to Constantinople, about the year 555. The eggs were hatched in the proper season by the warmth of a manure heap, the worms were fed with the leaves of the mulberry tree, and their race propagated under the direction of the monks.† The insects thus happily produced from this caneful of eggs, as if the little ark of the insect race, were the progenitors of all the silkworms of Europe, and the western parts of Asia. Vast numbers of these insects were soon reared in different parts of Greece, particularly in the Peloponnesus. The monks having also made themselves masters of the art of manufacturing silk, the business was conducted under the auspices of the emperor, and for his exclusive benefit: but the imperial monopoly could not long continue, and mankind gradually became possessed of the precious insects, after the death of Justinian, in the year 565.‡ The people of the Peninsula, and of the cities of Athens and Thebes, enjoyed the profit of the culture and manufacture of silk, without a European rival, for upwards of 400 years; and the Venetians, during the continuance of their commercial glory, distributed the products of their industry over the western parts of Europe. At length, Roger, the Norman king of Sicily, after his return from the second crusade, in order to anticipate

* Procopius, p. 34.

† The Monks procured the eggs from the colony of the Seres, in Little Bucharia.

‡ Procopius de Bello Gothico, lib 12, cap. 17.

an attack, which the government of Byzantium was preparing against him, and to revenge the insult of the imprisonment of his ambassadors, whom he sent to form a treaty and a matrimonial alliance with the Emperor Comnenus, made war upon Greece, in the year 1146, with a powerful naval and military force. Corcyra, the present Corfu, first yielded to the arms of the invaders, and the surrender of the other cities of Greece, and all the Morea, followed in speedy succession. The spoils were great. But what peculiarly distinguished this war from most others, which have no consequence than the exaltation of one individual, the depression of another, and the misery of thousands, was the capture of a great number of silk weavers, who were carried off and settled in Palermo, the capital city of the conqueror. By the order of the king, the Grecian prisoners taught his Sicilian subjects to raise and feed silkworms, and to weave all the varieties of silk stuffs; and so well did they profit by the lessons of their instructors, that, in the course of twenty years, the silk manufacturers of Sicily were subjects of notice and of praise, by the historians of the age.*

The Saracens had, before this time, obtained the knowledge of the various operations of the silk manufacture, and spread it over their widely extended dominions. Lisbon and Almeria, the two Saracen cities of Spain, were especially famous for their silk fabrics, and the islands of Majorca and Ivica paid their tribute to the kings of Arragon in silks. The Italian States soon after engaged in the culture and manufacture of silk, and in the year 1306, this business was so far advanced, as to yield a revenue to the State. In France, Louis the XI. and his son Charles the VIII established a number of Italian workmen at Tours; but it is to Henry IV that France is indebted, for placing the culture of silk and its manufacture upon a solid basis. Having put an end to the civil wars of the nation, he determined to give every possible encouragement to this important branch of industry, by recommending and enforcing the general planting of mulberry trees, and the rearing of silkworms. The merit of Henry, on this occasion, is increased by the fact, that his views and measures were in direct opposition to the advice of his favorite and wise minister, Sully, who held the project in little consideration, as appears by his own memoirs, in which he candidly records the discussions which he had with the king on the subject. In the year 1455, mention is made of a company of silk women in England. In 1504, the manufacture of ribbons, laces, and girdles, was so considerable, as to be protected by a prohibitory statute. In 1561, Queen Elizabeth was presented with a pair of black knit silk stockings, with which she was so well pleased, that she never after wore any of another material. James I. was extremely solicitous to encourage the silk manufacture, and recommended it several times from the throne: and in the year 1608, addressed a long letter on the subject, written with his own hand, to the Lord Lieutenants of every county in the kingdom, to whom mulberry

* Muratori Scriptor, Veter. vi. col. 668—Macpherson's Annals, vol. 1, p. 322.

plants and seeds were sent for distribution. He also had a book of instructions composed, on the rearing of the trees and the culture of silk, to promote the success of his project. The royal wishes do not appear to have been seconded by his subjects; but he had the satisfaction to see the broad silk manufactory introduced in the latter end of his reign. The revocation of the edict of Nantes, in the year 1685, which drove all the Protestants from France, permanently established the business in England; and the erection of the silk throwing mill of Sir Thomas Lombe, at Derby, in the year 1719, greatly promoted it, by the rapid preparation of the raw material.

HISTORY OF SILK IN THE UNITED STATES.

The culture of silk first commenced in Virginia. Upon the settlement of that colony, it was deemed an object of the first importance; and the attention of the settlers was strongly directed to it by the British government, by which silkworm eggs, white mulberry trees, and printed instructions, were sent over and distributed. King James the First, in the 20th year of his reign, having, doubtless, seen the defeat of his plan to encourage the silk culture at home, was induced to attempt it in Virginia; and, "having understood that the soil naturally yieldeth store of excellent mulberries," gave instructions to the Earl of Southampton, to urge the cultivation of silk in the colony, in preference to tobacco, "which brings with it many disorders and inconveniences." In obedience to the command, the Earl wrote an express letter on the subject, to the Governor and Council, in which he desired them to compel the colonists to plant mulberry trees, and also vines. Accordingly, "as early as the year 1623, the colonial assembly directed the planting of mulberry trees; and in 1656, another act was passed, in which the culture of silk is described as the most profitable commodity for the country; and a penalty of ten pounds of tobacco is imposed upon every planter who should fail to plant at least ten mulberry trees for every hundred acres of land in his possession. In the same year a premium of 4,000 pounds of tobacco* was given to a person as an inducement to remain in the country, and prosecute the trade in silk; and, in the next year, a premium of 10,000 pounds of tobacco was offered to any one who should export £200 worth of the raw material of silk. About the same time, 5,000 pounds of the same article was promised "to any one who should produce 1,000 pounds of wound silk in one year." The act of 1656, coercing the planting of the mulberry trees, was repealed, in the year 1658, but was revived two years after; and the system of rewards and penalties was steadily pursued until the year 1666, when it was determined that all statutory provisions were thereafter unnecessary, as the success of divers persons in the growth of silk, and other manufactures, "evidently demonstrated how beneficial the same

* In the early settlement of Virginia, tobacco was the circulating medium, the substitute for money, as sewing silk is, in part, at present in Windham county, Connecticut.

would prove." Three years after, legislative encouragements were revived, but subsequently to the year 1669, the interference of government seems entirely to have ceased.* The renewal of the premiums after the act of the year 1658, was, doubtless, owing to the recommendation of Charles II: for, in the year 1661, among the instructions given to Sir Wm. Berkeley, upon his reappointment as governor, and while in England on a visit, the king recommended the cultivation of silk, and mentioned, as an inducement to the colonists to attend to his advice, "that he had formerly worn some of the silk of Virginia, which he found not inferior to that raised in other countries." This remark is probably the ground of the tradition mentioned by Beverly, that the king had worn a robe of Virginia silk at his coronation.†

The revived encouragement given by the Colonial Legislature to the culture of silk, had the desired effect. Mulberry trees were generally planted, and the rearing of silkworms formed a part of the regular business of many of the farmers. Major Walker, a member of the Legislature, produced satisfactory evidence of his having 70,000 trees growing in the year 1664, and claimed the premium. Other claims of a like tenor were presented the same session.‡ The eastern part of the State abounds at present with white mulberry trees; and it is to be hoped the people will see their interest in renewing the culture of silk.

Upon the settlement of Georgia, in 1732, the culture of silk was also contemplated as a principal object of attention, and lands were granted to settlers upon condition that they planted one hundred white mulberry trees on every ten acres, when cleared; and ten years were allowed for their cultivation. Trees, seed, and the eggs of silkworms, were sent over by the trustees to whom the management of the colony was committed. An Episcopal clergyman and a native of Piedmont were engaged to instruct the people in the art of rearing the worms and winding the silk; and in order to keep alive the idea of the silk culture, and of the views of the Government respecting it, on one side of the public seal was a representation of silkworms in their various stages, with this appropriate motto: "Non sibi sed aliis."§ By a manuscript volume containing "the account of the moneys and effects received and expended by the trustees of Georgia," to which the writer has had access, it appears that the first parcel of silk received by the trustees, was in the year 1735, when eight pounds of raw silk were exported from Savannah to England. It was made into a piece, and presented to the queen.‖

* Henning's Statutes of Virginia, vol. 1 & 2.—Letter to the Secretary of the Treasury in answer to the silk circular, from the Honorable John Tyler, late Governor of Virginia.

† Burke's Hist. Virginia, vol. 2. p. 125.

‡ Burke, vol. 2. p. 241.

§ M'Call's History of Georgia, vol. 1. p. 22. 29.

‖ "The trustees of Georgia waited on her majesty with some silk from Georgia, which had proved very good. It is to be wove into a piece for her majesty."—Gentleman's Mag. Vol. 5, p. 448. The following entry appears in the manuscript book of the trustees, under date 1736: "The raw silk from Georgia, organzined by Sir Thos. Lombe, was made into a piece of silk, and presented to the queen." Under date 1738, is a charge "for making a rich brocade, and dying the silk from Georgia, £26."

From this time, until the year 1750, there are entries of large parcels of raw silk received from Georgia, the produce of cocoons raised by the inhabitants, and bought from them, at established prices, by the agents of the trustees, who had it reeled off under their direction. In the year 1751, a public filature was erected, by order of the trustees. "The exports of silk, from the year 1750 to 1754, inclusive, amounted to $8,880. In the year 1757, one thousand and fifty pounds of raw silk were received at the filature. In the year 1758, this building was consumed by fire, with a quantity of silk, and 7,040 pounds cocoons; but another was erected. In the year 1759, the colony exported upwards of 10,000 weight of raw silk, which sold two or three shillings higher per pound, than that of any other country."* According to an official statement of William Brown, Comptroller of the Customs of Savannah, 8,829 pounds of raw silk were exported between the years 1755 and 1772, inclusive.† The last parcel brought for sale to Savannah, was in the year 1790, when upwards of two hundred weight were purchased for exportation, at 18*s.* and 26*s.* per pound.‡

Some attention was also paid, in early times, to the culture of silk in South Carolina; and the writer has been informed, that, during a certain period, it was a fashionable occupation. The ladies sent the raw silk produced by them to England, and had it manufactured. "In the year 1755, Mrs. Pinckney, the same lady who, about ten years before, had introduced the indigo plant into South Carolina, took with her to England a quantity of excellent silk, which she had raised and spun in the vicinity of Charleston, sufficient to make three complete dresses: one of them was presented to the Princess Dowager of Wales, and another to Lord Chesterfield. They were allowed to be equal to any silk ever imported. The third dress, now (1809) in Charleston, in the possession of her daughter, Mrs. Horry, is remarkable for its beauty, firmness, and strength."§ The quantity of raw silk exported as merchandise was small; for during six years, only 251 lbs. were entered at the custom house.|| The quality of it was excellent: according to the certificate of Sir Thomas Lombe, the eminent silk manufacturer, it had as much strength and beauty as the silk of Italy.¶ At New Bordeaux, a French settlement, 70 miles

* M' Call's Hist. Georgia, vol. 1. p. 251.

† It will be seen that this statement differs from that of Mr. M'Call. It first appeared in B. Roman's account of Florida, and afterwards in Aikin's Pennsylvania Magazine, for July, 1775. An opinion of the quality of the Georgia silk, may be formed from the following document:

"A paper was laid before the Commissioners for Trade and Plantations, by about forty eminent silk throwsters and weavers, declaring, that, having examined a parcel of about 300 pounds weight of Georgia raw silk, imported in February last, they found the nature and texture of it truly good, the color beautiful, the thread even, and clean as the best Piedmont, and will be worked with less waste than China silk."—London Magazine for 1755.

‡ The late Charles Harris, Esq.: letter to the Secretary of the Treasury.

§ Ramsay's History of South Carolina, vol. 1. p. 221.

|| Viz: in the years 1742, 1748, 1749, 1750, 1753, 1755.—Dodsley's Annual Register, 1761.

¶ An Impartial Enquiry into the State of Georgia.—London, 1741, p. 79.

above Augusta, the people supplied much of the high country with sewing silk, during the war of the Revolution.*

In the year 1771, the cultivation of silk began in Pennsylvania and New Jersey, and continued with spirit for several years. The subject had been frequently mentioned in the American Philosophical Society, as one of those useful designs which it was proper for them to promote; but they were induced to enter into a final resolution on it in consequence of a letter being laid before them on the 5th January, 1770, from Doctor Franklin, who was then in London as Agent of the Colony, and in answer to one which had been written to him on the same subject by the late Doctor Cadwallader Evans. In this letter from Doctor Franklin, he recommended the culture of silk to his countrymen, and advised the establishment of a public filature in Philadelphia, for winding the cocoons. He also sent to the Society a copy of the work by the Abbe Sauvage, on the rearing of silkworms. A committee having been appointed by the Society to frame a plan for promoting the culture of silk, and to prepare an address to the Legislature, praying for public encouragement of the design, they proposed to raise a fund, by subscription, for the purchase of cocoons, to establish a filature, and to offer for public sale all the silk purchased and wound off at the filature: the produce thereof to be duly accounted for, and to remain in the stock for carrying on the design. A subscription among the citizens was immediately set on foot, and the sum of £875 14*s.* obtained the first year;† eggs and white mulberry trees were imported, and a digest of instructions composed, published, and distributed. Until the white mulberry trees were fit to allow of their leaves being plucked, the worms were fed upon the leaves from the native trees, and were found to agree perfectly well with them, and to yield excellent silk. It is believed that all the silk produced during the continuance of the Society, was from food furnished by native trees. A spirit for the silk culture was excited among the citizens, and many garments are still possessed by families which were made from silk raised by their forefathers. The war of the Revolution put an end to the patriotic association, and suspended, in a great measure, the silk culture—there being no longer a sale for cocoons; but many persons continued their attention to it, and others resumed it after the termination of the war.

The knowledge of the proper mode of rearing silkworms, and of winding the silk, was greatly promoted by the publication of a paper on those subjects, in the 2d volume of Transactions of the American Philosophical Society of Philadelphia, which the late Doctor John Morgan procured from Italy, through a silk mercantile house in Lon-

* Thomas McCall, Esquire: answer to the silk circular.

†The loss of the minutes of the Society prevents our knowing the amount subscribed in subsequent years. It is a proof of the anxiety of the British Government, in respect to the silk culture in the Colonies, that, in the year 1769, an act was passed for the '*further*' encouragement of the growth of silk in North America, granting 25*l.* for every 100*l.* value of raw silk raised for the next seven years, and smaller bounties during the two following periods of seven years. But no mention is made of this act by Doctor Franklin in his letter, nor does it appear that any premium was claimed by the Society in consequence of it.

don.* During the last three years, a spirit has been revived and diffused on the subject, and promises to increase; and there can be no hesitation in saying, that a ready sale for cocoons is alone wanting, to establish the silk culture as a regular employment in several States of the Union. It was the want of this market which defeated, in a great degree, the patriotic attempt of Mr. Nathaniel Aspinwall, of Connecticut, about the year 1790, to revive the silk culture in Pennsylvania, New York, and New Jersey. But his memory deserves to be held in everlasting and grateful remembrance, for the thousands of white mulberry trees which he planted in those States, and for the commendable zeal he exhibited in the cause.

In Connecticut, attention to the culture of silk commenced about the year 1760, by the introduction of the white mulberry tree, and eggs of the silkworms, into the county of Windham, and town of Mansfield, from Long Island, New York, by Mr. N. Aspinwall, who had there planted a large nursery. He also planted an extensive nursery of the trees in New Haven, and was active in obtaining of the Legislature of Connecticut, an act granting a bounty for planting trees; a measure in which he was warmly supported by the patriotic and learned Dr. Ezra Styles. The premium was ten shillings for every hundred trees which should be planted and preserved in a thrifty condition, for three years; and three-pence per ounce for all raw silk, which the owners of trees should produce from cocoons of their own raising within the State. After the public encouragement for raising trees was found unnecessary, a small bounty on raw silk, manufactured within the State, was continued some time longer. A statute continues in force, requiring sewing silk to consist of twenty threads, each two yards long.†

It would be an act of injustice to omit noticing the generous encouragement to the cultivation of silk in the American Colonies, which was given by the patriotic Society in London, for "the Promotion of Arts," &c. From the year 1755 to 1772, several hundred pounds sterling were paid to various persons in Georgia, South Carolina, and Connecticut, in consequence of premiums offered by the Society, for planting mulberry trees, and for cocoons and raw silk.‡

After the war of the Revolution, the business was renewed, and gradually extended; and it is recorded, that, in the year 1789, two hundred pounds weight of raw silk were made in the single town of Mansfield, in Windham, Connecticut.§ In the year 1810, the value of the sewing silk and raw silk, made in the three counties of New London, Windham, and Tolland, was estimated, by the United States' Marshal, at $28,503;‖ but the value of the domestic fabrics made

* This excellent paper has been copied in all the British and Scoth Encyclopædias, and was reprinted in a pamphlet, at Windham, Connecticut, in the year 1792.

† Governor Wolcot's answer to the silk circular.

‡ The particulars are not inserted in the transactions of the Society, but may be seen in Bayley's Advancement of the Arts, London, 1772, and in Dossie's Memoirs of Agriculture, vol. 3.

§ Columbian Magazine, Philadelphia, 4, p. 61.

‖ Statement of the arts and manufactures of the United States for the year 1810. By Tench Coxe.

from the refuse silk, and worn in those counties, was not taken into consideration. They may be fairly estimated at half of the above sum. In the year 1825, inquiries were made by the writer, in Windham county, as to the increased attention to the silk culture there, and it was found that the value of the silk, and of the domestic fabrics manufactured in that county, was double that of the year 1810. It was also found, that sewing silk was part of the circulating medium, and that it was readily exchanged at the stores for other articles, upon terms which were satisfactory to both parties, and that the balance of the account, when in favor of the seller, was paid in silver. The only machines for making the sewing silk, are the common domestic small and large wheels; but practice supplies the defects of these imperfect implements. With better machinery, sewing silk of a superior quality would be made. At present, "three-fourths of the families in Mansfield, are engaged in raising silk, and make, annually, from 5 to 10, 20, and 50 pounds in a family, and one or two have made, each, 100 pounds in a season. It is believed that there are annually made in Mansfield, and the vicinity, from three to four tons.*

The farmers consider the amount received for their sewing silk as so much clear gain, as the business does not interfere with the regular farm work of the men, or the domestic duties of the females, upon whom, with the aged and youthful members of the family, the care of the worms, and the making of the sewing silk, chiefly devolves. It is known also, that in the other New England States, Maine excepted, more or less attention to the silk culture is given.

During the late war with England, Samuel Chidsey, of Cayuga county, New York, sold sewing silk to the amount of $ 600 a year. Mr. C. introduced the white mulberry tree in the town of Scipio, on its first settlement.† Silk was, also, formerly raised by the French inhabitants, in the country now the State of Illinois, but to what extent is not known.‡

The cultivation of silk has commenced in the States of Ohio and Kentucky, and there is every reason to believe that it will extend. The first mentioned State contains a great number of citizens who formerly resided in the silk-growing districts of Connecticut and Massachusetts, and who will doubtless see their interest in renewing a branch of business from which they formerly derived so much profit. In the latter State, it is chiefly confined to those industrious people, the United Brethren, whose steady, persevering labors and intelligence, are the surest guarantees of success.

* Z. Storrs, Esq. of Mansfield: answer to the silk circular.

The manufacture of silk is chiefly confined to the counties of Windham and Tolland. The quantity made in five towns, last season, 1827, according to an accurate statement, was as follows:

Mansfield	2,430 lbs.	Ashford	500 lbs.	Coventry	350 lbs.
Chaplin	550 do.	Hampton	467 do.		

Worth four dollars per pound. The value increases one-fourth in manufacturing. Several towns in which much silk is made, gave no returns. Letter to the Secretary of the Treasury, by D. Bulkeley, Esq.

† Mr. David Thomas: letter in answer to the silk circular.

‡ Governor Coles: letter in answer to the silk circular.

CHAPTER I.

NATURAL HISTORY OF THE SILKWORM.

The phalæna, or moth of the silkworm, or, more properly, the silk-caterpillar, is about an inch long, and nearly an inch and a half between the extremities of the largest wings, when extended. The bodies of both male and female, are obscurely white, and thickly covered with short hairs. There are two antennæ;* the stems are whitish, and lateral fillets pectinated, or like the teeth of a comb. In the male, they are unequally spaced, while in the female, they are smooth, less pectinated, shorter, and not so close, and, in a state of repose, they commonly lie on their sides. There are four transparent wings, of the same color as the body. In the male, the upper surface of the superior wings are crossed by two brown bands; the broadest one is near the extremity of the wing, and is continued on the under wing. Both bands are bordered with a line: on the under surface there is only one band. The superior wings are a little bent downwards at their ends. The inferior wings of both are reverse in a state of rest, and extend beyond the upper ones. The wings are covered with a white powder.

The tail of the male is somewhat raised and square. The female is larger than the male; her wings are less strongly marked with bands, and on the exterior margin of the wings. On the wings of both, are several rays, which are as apparent on the under as the upper surfaces. These are termed nervures, and are hollow tubes, proceeding from the commencement of the wings, and diminish gradually in size, (the marginal one excepted) to their termination. The vessels contained in these nervures, consist of spiral threads, whence they appear to be intended to be air vessels communicating with the air vessels in the body.† The wings are flat, and incapable of contraction or dilatation. There are two black convex eyes, one on each side of the head. They are protuberant, and rise above the head rather more than a hemisphere. To the naked eye, their surface appears to be plain; but, by submitting them to the microscope, their true and admirable structure is ascertained. By the help of this instrument, it is found that the whole surface consists of a multitude of lenses, all separated from one

* The antennæ are commonly called feelers, from the circumstance of numerous insects touching substances with them; but all antennæ are not thus used, nor are they formed to answer this purpose.

It is now supposed that they are, in some way, connected with the organ of hearing; and that they may collect and transmit sound to such an organ, the minuteness of which defies investigation. This organ is suspected to be at the base of the antennæ, the spot in which the same organ has been discovered in the crayfish. Kirby and Spence on Insects, vol. 3. pp. 43. 46, vol. 4. p. 246.

† These nervures are not peculiar to the moth of the silk-caterpillar, but common to the wings of most insects.

another by an hexagonal or six-sided figure, and placed in the most exact order. Leewenhoek counted thirty-five of these lenses on the fourth part of the sphere of one eye; the entire circumference will therefore contain 140; hence, he says, it follows, that each eye is composed of 3,000 optical organs; but, if both parts together constituted a sphere, they then contain 6,236. When the eye is separated and made clear, these hexagons are as transparent as crystal. Leewenhoek having properly prepared and fitted an eye to a microscope, could see through it clearly, but the largest objects viewed, were diminished to an incredibly small size. The steeple of the church in Delft, which is 300 feet high, at 750 feet distance, appeared no larger than the point of a needle, seen by the naked eye.

Not huge Behemoth, nor the whale's vast form,
That spouts a torrent, and that breathes a storm,
Transcends in organs apt this puny fly,
Set with ten thousand lenses.*—*Evans.*

The construction of these compound eyes, is admirably adapted to the convenience of the insect; for, as they are immovable, they would have lost sight of many objects, if their eyes had been framed like those of other animals; but, by their form, they can easily see surrounding objects. As we do not see double with our eyes, so the numerous inlets to sight in an insect, may increase their field of view.

When the worm is first hatched, it is very minute, and of a brown hue, if healthy. This hue is derived from the hairs covering its body: they disappear in the course of a few days, when it assumes a light or dark hue, according to the nature of the particular variety. Behind the head, the skin is formed into six wrinkles. The body is composed of twelve articulations, or rings: each ring, except the second, third, and last, is marked on the sides, and near the belly, with spots of a deeper color than that of the skin, and show oval openings through which the insect respires. These openings are termed spiracula,† or breathing holes, and communicate, internally, with two air vessels, running the whole length of the body, one on each side, in a straight line, from one spiracle, or stigma, to another, and, uniting near the head, form one trunk. They serve, or perform, the office of lungs. In other words, these stigmata are eighteen mouths, which admit air into the principal air vessels in the large trunks of the trachea, or wind-pipes, whence it is led to the different and numerous ramifications of the air tubes, to the intestinal canal, to the other internal parts, and to the skin.

* The number of lenses in an eye, varies in different insects. Leewenhoek counted 8,000 in that of a common house fly. *(a)* Hooke *(b)* computed 7,000 in a horse fly; and Puget *(c)* 17,325 in that of a butterfly.

† Malphigi and Reaumur call them stigmata.

(a) Select works, 4to. vol. 1. p. 62. Lond. 1796. *(b)* Micrographia, p. 176.
(c) Amœnitates Academicæ. vol. 3. p. 141.

The silk-caterpillar has sixteen feet. The three first pair are scaly and hard, and placed under the three first rings, one on each side. The next two rings are destitute of feet. The four succeeding rings have each two feet. These are soft and membranous, and swell, contract, and expand, at the will of the insect. The next two rings are without feet; the last ring has two feet. The extremities of the twelve membranous feet, are furnished with hooks, or claws, the number of which, according to the accurate Malphigi, are forty* in number in each foot. They are of different sizes, and are placed in double and equi-distant rows. The extremities of the six first feet, consist of curved nails, or hooks, which enable the caterpillar to hold to the spot to which it has been pushed by the contractions of the posterior rings. These feet are the envelopes of those which appear in the moth. The others remain with the cast off skin of the caterpillar.

On the last ring but one, is placed a small horn, if that can deserve this name, says Reaumur, which is used neither as a weapon of attack nor defence. This accurate naturalist acknowledges his inability to point out its use. The head of the caterpillar is formed of two scaly spherical pieces, which do not touch, but leave a triangular space between them. On each side of these pieces, and in front, six or seven black spots, arranged in a circle, may be seen: these are the eyes. The opening between these two pieces, below and in the forepart, is the mouth. It is armed with two parallel jaws, and with teeth, which move horizontally when the insect eats. The spinnaret, or silk hole, is near the summit of a pyramidal substance, occupying the middle of the lower lip, and terminates in a little papilla of a black form, from the point of which the silk filament issues that forms the cocoon. The canal which receives the aliment, proceeds, in a straight line, from the mouth to the vent, and is of different capacities, analogous to the gullet, the stomach, and intestines, of animals. The vessels in which the silk is formed, consist of two parallel tubes of the same size, which are so extremely delicate near their termination, as to appear to unite in one tube; but, by immersing and hardening the insect in spirits of wine, Reaumur† found that they continued separate to their ends, and that he could take them out entire: they are about one foot in length. The use of the microscope confirmed the structure: for, by the help of this apparatus, he discovered that the fibre of silk, minute as it is, instead of being round, as it would be if it proceeded from one vessel, had more breadth than thickness, and that, in the middle of each fibre, there was a kind of furrow, giving the appearance of two flattened cylinders glued together. In some threads, he even saw the separation, or forks, at the end of the thread‡ From the contracted nature

* De Bombycibus, p. 9; Malphigi Opera Londini, 1737.

† Memoire sur insects, p. 147, Paris, 4to. 1734.

‡ Memoire, p. 499. In this admirable work, Reaumur has shown this confirmation of the silk thread in magnified figures. Plate 5, fig. 4; plate 32, fig. 13, 14, 15; plate 33, fig. 1, 2, 3. Leewenhock had, many years previously, demonstrated this structure by the microscope. Lyonet, however, questions the accuracy of both, and insists that both silk tubes unite before they reach the orifice. Traite Anatomaque de la Chenille, &c. p. 55. A la Haye, 1762.

of the sides, and the form of the orifice, combined with the power the insect has of moving it in every direction, results the difference we see in the breadth and form of the threads, and the various thickness of the same thread.*

The silk reservoirs, following the course of the stomach, extend as far as the last pair of membranous feet, then fold back on each side, and proceed to the head, and, after two more turnings, the tubes lessening in size, they end in a series of convolutions.† Each of these vessels is filled with a glutinous matter, near the time of spinning the cocoon, generally of the color of the silk which the caterpillar will spin. Sometimes it is of different colors in the same vessel; the upper part containing a yellow liquor, and the lower portion of it a pale liquor. The quality of the leaves, and the constitution of the insect, are the probable causes of this circumstance. While in the silk-secretors, it assumes the appearance of a viscid gum; but the moment it is exposed to the air, after being thrown out by the worm, it dries and hardens into a single thread.

The silk-caterpillar, whose life is one continued succession of changes, casts off its skin four times before it reaches its full growth. This is a wonderful provision of nature, although, as is well known, not confined to this insect, to relieve itself from the constriction it suffers from the skin, which does not expand in proportion to the gradual increase of its body. These changes are times of pain to the caterpillar, which it shows by a state of languor, and by ceasing to eat. It prepares for the operation, by emptying the intestinal tube, and by throwing out, at different parts of its body, silky fibres, and attaching them to the litter of its food, in order that, while it exerts itself, the skin may remain fixed in the spot where it is placed. The insect is now seen, at intervals, with its back elevated, or with its body stretched to the utmost extent, sometimes raising its head, which is swelled and pointed, moving from side to side, and then letting it fall. Near the change, the second and third rings are seen considerably swollen.

By these internal efforts, the old parts are stretched and distended, and a slit is made on the back, generally beginning at the second or third ring. The new skin may now be perceived by its freshness and brightness of color. The caterpillar then presses the body into this opening, by which means, and a continuance of swellings and contractions, a rent is made from the first to the fourth ring. Then, bending the forepart of its body, and drawing it backwards, it disengages the head from its old covering, and throws it out of the slit. Finally, curving the posterior rings, and drawing them towards the head, the whole body escapes from its sheath. This escape is facilitated by a moisture, which the insect emits and diffuses over its body.

This laborious operation is the work of an instant; and the skin, when cast off, is so entire, that it might be mistaken for the larva or caterpillar itself, comprising, not only the covering of the trunk, but of the very skull, eyes, jaws, and legs. These changes are termed

* Kirby and Spence's Introduction to Entomology, vol. 3, p. 125, Lond.

† When taken out and extended, they measure a foot and seven inches in length

moultings, and take place at different intervals, and continue for various periods, according to the climate or temperature in which the insects have been kept, their particular nature, the quality of the food, and the quantity and regularity with which they have been supplied.* In this country, in a general way, the silk-caterpillars of four casts or moultings, which have been, in all respects, properly treated, show symptoms of their first moulting on the fourth or fifth day after they are hatched.

The appearances which the worm assumes in the various stages of its life, will be mentioned in the course of the details of its progress to maturity, and therefore need not be here anticipated.

Sometimes a part of the covering remains attached to the extremity of the caterpillar, which cannot cast it off. The insect then swells or enlarges in the part which is disentangled, while the other part of the body continuing compressed, occasions its death.

After having recovered from a moulting, the new skin is pale and wrinkled; the insect appears much larger than before, owing to the room given for distending its body under the new skin, and feeds with increased activity. This increase of appetite is in proportion to the advanced age of the insect; but, after the fourth moulting, it is very great, and the consumption of leaves is immense. The last casting of the skin, which is visible, being finished, and the caterpillar having attained its greatest size, and matured the silky material in its vessels, it loses all appetite, ceases to eat, and consequently to grow, and then diminishes in weight and size. It relieves itself of the contents of the alimentary canal, which are now soft and green, instead of hard and black as before, and contracts its skin, and whole body, to such a degree, as to be readily perceptible. These appearances take place about nine or ten days after the fourth moulting. The caterpillar now begins to prepare for spinning the silky tomb in which nature has destined that it should enclose itself. It first wanders about, and raises up its head, as if searching for a place to commence work, and, having fixed on a suitable spot, it throws out some loose threads, and glues one end of them to an adjoining surface. These threads it next conducts to another part, and then fastens them; repeating this process, and interlacing them in various directions, until it has surrounded itself with a slight and loosely spun netting. In the centre of this, when contracted into a space sufficiently small, it lays the foundation of the interior cocoon. Fixing itself to some of the surrounding threads, it bends its body, and, by successive motions of the head from side to side, spins a layer of silk on the side opposite to it; when this is of the requisite thickness, the insect shifts its position, and repeats the same process in another quarter,† covering each layer, in turn, with a new one, until the interior cavity is reduced to the size desired. Thus, the silken thread which forms the cocoon, is not, as

* In India, during Summer, the moultings are finished in a few hours.—Anderson's Bee, Edin. vol. 8, p. 39.

† See Plate 3, figs. 4 and 5, for a view of the precise mode in which the silk fibres are laid.

might be supposed, wound circularly, as we wind the thread of a ball of cotton, but backwards and forwards, in a series of zigzags, so as to compose a number of distinct layers. Malphigi* distinguished six of these layers; and Reaumur† suspects there is often a greater number. Hence, when the cocoon is wound off, the unravelling proceeds in a very irregular manner. The inside is smeared with a gum of the same nature with that out of which the silk is formed.

The construction of the cocoon is a work of three days, or three days and a half. During the first day, the insect forms the exterior envelope, which is merely the scaffolding, by means of which the inner and more solid covering is constructed. On the second, it forms the ball, and covers itself with silk. The third day, the insect is quite hid, and afterwards it is employed in thickening and strengthening the ball. Having done this, the caterpillar has to undergo a second change of form, viz: into that of a chrysalis; that state intervening between the larva, or caterpillar, and imago, or perfect moth, in which its parts and organs are fully prepared, and fitted for their final and complete developement in the last mentioned state. This state is assumed on or about the fourth day after having spun its cocoon. In this state it is quiescent, and apparently without life, but all this time a new organization is internally forming. The first operation it performs, is to cast off the external skin, which covered it in the caterpillar state, with the head and jaws attached to it. This it does in one or two days after finishing its cocoon, and, according to Malphigi, in the space of one minute and ten seconds;‡ who adds, that the act is greatly promoted by a yellowish fluid, discharged from the cavity of the head, which enables the outward skin the more easily to slip over it, as the insect contracts and elongates. The caterpillar thus stripped, is called the pupa. The exterior covering gradually becomes hard, while the interior remains so soft, that the slightest touch will decompose it. The stomach is filled with yellow mucus, which is doubtless the source of nourishment to the pupa. The germs, or rudiments, of the future moth, which, according to Swammerdam, may be detected even in the caterpillar, near its last change, in a semi-fluid state,§ gradually develop, and assume their destined form; the wings, rolled up, are lodged between the second and third rings: the antennæ are placed alongside of them; the legs are actually sheathed in legs; and when they have acquired a proper degree of solidity, a slight inflation of the body is sufficient to split the membrane which covers them. A repetition of these motions enlarges the slit, and affords the moth room to escape from its confine-

* De Bombycibus, p. 24.

† Tome 1, p. 498.

‡ De Bombycibus, p. 25.

§ To discover these, it is directed to drown the caterpillar, when about to assume the pupa state, in vinegar, or spirits of wine, and to let it remain there for several days, to harden the parts: or to boil it for a few minutes, then to dissect off the skin, when the enclosed moth will appear, but the parts are in a different manner from that in which they lie in the pupa.

ment. If the cocoon be opened, it is easy to discover the efforts which the insect makes to free itself. When the operation begins, there seems to be a violent agitation in the humors of the little animal; the fluids being driven with rapidity through all the vessels, the limbs and other parts are put in motion, and, by repeated efforts, it breaks through the brittle skin that envelopes it.

Another operation remains to be performed; this is, to penetrate the tough, silky cocoon, with which it is covered.

It has been a question how the moth escapes from the cocoon. Malphigi* asserts that it first wets the end of the cocoon with a liquid, calculated to dissolve the gum which glues the fibres together, and then employs its head to push them aside, and make an opening. But, as Reaumur has observed,† besides, that so obtuse a part as the head of a moth is but ill suited to act as a wedge, we find the threads not merely pushed to each side, but actually cut asunder. He therefore infers, that the eyes are the instruments by which the threads are divided—their numerous minute facets serving the purpose of a fine file. The Rev. Mr. Swayne‡ supports the idea of Malphigi. He informs us that he has unravelled several pierced cocoons, but never found that the thread was discontinued in any one instance. He remarks, however, that, whenever this is attempted, it must be with the cocoon dry, as the silk will be immediately entangled when put into hot water. Analogy is against the opinion of Reaumur, since other kinds of silkworms make their escape by means of a fluid, as the *Attacus Paphia*, of India, described by Dr. Roxburgh.§ Perhaps the two opinions may be reconciled, by supposing that the silkworm first moistens, and then breaks the fibres of the cocoon, by the united assistance of his jaws and head. This is the opinion of Mr. Swayne.

The time occupied by the silk-caterpillar in going through its different forms of existence, varies in different countries; and depends upon climate, the temperature in which they have been kept, food, and the nature of the particular variety of insect.

These circumstances, which are the true causes, will explain the different statements of various writers on the subject, all of whom profess to speak from actual observation. It will be hereafter seen, too, that the temperature of the room in which the eggs have been kept, during the winter, affects the periods at which they hatch.

In general, silk-caterpillars, of four casts, when treated carefully, according to the system laid down by the experienced Dandolo—that is, gradually brought to maturity by a due regulation of the heat of the apartment, experience their first change or moulting on the fourth and fifth days after they have left their eggs: the second commences on the eighth day, and ends on the ninth: the third occupies the thirteenth and fourteenth days: the fourth, and last, is effected on the twenty-first and twenty-second days. The fifth age lasts ten days, at

* De Bombycibus, p. 29.
† Reaumur, Hist. des Insects, tome 1, p. 624.
‡ Trans. Soc. Arts, Lond. vol. 7, p. 132.
§ Trans. Linnæan Soc. Lond. vol. 7, p. 35.

the end of which time the caterpillars have reached their ultimate growth, are three inches in length, and of the size of a swan's quill, or even larger, and prepared to spin their cocoons. Each moulting takes up about two days: making, in all, about thirty-two days from the hatching of the insect.

In Pennsylvania, where artificial heat has not yet been generally employed, the worms which have proceeded from stocks long among us, come to maturity in about forty-two days; in Mansfield, Connecticut, in about five weeks. The small white worms, of the same place, which produce beautiful and fine white silk, and two crops annually, feed twenty days. A part of the worms produced from eggs imported in the spring of 1826, from Genoa, by the writer, and reared in the Pennsylvania Hospital, came to maturity in twenty-six days.

The length of time passed by the worm in the state of a chrysalis, depends much upon the degree of heat in which the cocoons are kept. If the temperature be about 66° of Fahrenheit's thermometer, the moths will make their appearance after fifteen days; while, on the contrary, the experienced Abbe Sauvage informs us, that he has prevented them from coming forth for a month, by keeping the cocoons in a vault.* This is very important information, as, by having recourse to this expedient, time will be given to wind off the cocoons, without baking or steaming them to kill the chrysalis.

In whichever way the cocoon is pierced, as soon as the head of the moth is out, the efforts he makes to bring forward the rest of his body, increase the opening; his two forward legs are soon out, and then, attaching them strongly to the exterior part of the cocoon, he uses this as a new support; other legs come out, and finally the whole moth escapes, leaving behind, in the cocoon, his caterpillar's skin, in a crumpled state, with the head and jaws attached thereto, and the shell of the chrysalis. Having gained their liberty, the moths discharge a red excrementitious fluid: neither of them attempts to fly: the male, anxious to fulfil the destiny of his nature, goes immediately in search of the female, fluttering his wings with great rapidity, and having found one, couples with her, continuing, for some time, to flap his wings. After different intervals of time, they separate, and the male soon after dies; the female crawls about, and lays from 200 to 450 minute eggs, and then she also dies. The eggs, when first laid, are of a pale yellow color; but, in the course of eight or ten days they assume a reddish gray hue, and, some time after that, a pale slate color. The unimpregnated, and consequently sterile eggs, remain yellow, and are more depressed on their surface than good eggs.

*Sur l'Education des Vers a Soie. 3d Memoir, p. 143.

CHAPTER II.

VARIETIES IN SILKWORMS.—*(Bombyx Mori.)*

1. *Of small Silkworms of three casts or moultings.*

I have reared, says Dandolo, a quantity of these silkworms separately, the eggs of which may be found in several parts of Lombardy. The worms and cocoons of this variety are two-fifths smaller than those of the common sort. His experiments demonstrated, that these worms consume, to form a pound of cocoons, nearly as much leaves as the large species; and, although smaller when they have reached their full growth, they devour more fragments and shoots of leaves than the common sort. Their cocoons are composed of finer and more beautiful silk than the common cocoon: they are also better constructed, and to this is owing the greater quantity of silk, which, at equal weights, is drawn from those cocoons, than from common cocoons. This variety, in the opinion of Dandolo, should be infinitely more cultivated than it has hitherto been: for,

1. These silkworms require four days less of care than the common silkworms.
2. They afford a saving of time, labor, and money.
3. They are not so long exposed to accidents—their life being shorter.

Some imagine the species to be delicate, but they appeared to Dandolo to be strong and vigorous. Six hundred cocoons weigh a pound and a half.

2. *Of large Silkworms of four casts.*

Dandolo reared many of these silkworms of a very large quality. The eggs came from Friuli: they produce larger worms and larger cocoons, yet they are not much larger nor much heavier than the eggs of the common species. The worms, at their full size, weigh nearly twice and a half as much as the common worm. The cocoons are in the same proportion: 150 of the large sort weigh a pound and a half, while it requires 360 of the common cocoon to weigh as much. The silk is coarser and not so pure as that of the common kind; the worms are five or six days later in attaining their full growth, and in rising, than the common silkworm.

3. *Of the Worms that produce white Silk.*

"I have raised," says Dandolo, "a large quantity of these, and found them, in all respects, equal to the common silkworms of four casts. If I reared silkworms for the purpose of spinning the silk myself, I would cultivate only the silkworm of three casts, and those that produce white silk, as preferable to all others; and every year would choose the very whitest and finest cocoons, to prevent the degeneration of the species."

This species was introduced into France about forty-five years since,

from China, but was not much cultivated until about seventeen years past. It is now highly prized by the manufacturers, as appears by the report of the exhibition of French Industry, in the year 1819.*

In Windham county, Connecticut, there is also a small pale white worm, which eats but twenty days, and produces fine white silk, though in less quantity than either the common large pale white, or the dark colored worm; but it has the good quality of retaining its clear white color, and does not turn yellow by washing, or by exposure to sun and air. These worms produce also two crops. It is highly probable that these white worms are of the same species as that last mentioned.

The dark drab colored worms, which are very common in the United States, and called "black," live longer, and make more silk than the large white worms.

4. *Silkworms of eight crops.*

At the silk establishment of the British East India Company at Jungepore, Bengal, Lord Valencia, besides the common annual silkworm which gave but one crop, found two others; the one commonly reared, and supposed to be indigenous, is called Dacey, producing eight harvests. Another and worst, the China, or Madrassa, also yields eight times a year.† This last may be the kind mentioned by Arthur Young, who says, he "obtained a silkworm from China, which he reared, and in twenty-five days had the cocoons in his basins, and by the twenty-ninth or thirty-first days, a new progeny feeding in his trays." He justly remarks, that "they would be a mine to whoever would cultivate them."‡ The American who would introduce any of the best of these silkworms into the United States, would render an essential service to his country. If circumstances, however, should prevent the importation of the species before mentioned, it is presumed there will be no difficulty in procuring, from the Isle of France, the eggs of those which came from Bengal in the year 1815, and were reared under the direction of Mr. Chazel, and which breed three times a year;§ or the variety of Madrass, which, according to Dr. Anderson, finish their course in forty days, viz: six days in eggs, twenty-two a worm, eleven in the cocoon, and one a moth.||

On rearing two or three crops of worms in the United States, in one season.

In those States where the heat continues long, more than one crop of worms can be obtained in a season without artificial means, as the following statement shows:

"In the month of March, 1826, Mr. Seth Millington,¶ received a

* Malphigi, long since, mentioned the existence of a variety of silkworms in Italy, which bred twice in a season.—De Bombycibus, p. 43.

† Travels to India in 1802, 1806, vol. 1, p. 78, Lond. 1809.

‡ Annals of Agriculture, vol. 23, p. 235

§ Transactions Soc. Arts, London, vol. 42.

|| Anderson's Bee, vol. 8, p. 342, Edinburgh.

¶ Of Prairie Haut, St. Charles Co. Missouri: letter to the Secretary of the Treasury, in answer to the silk circular.

few silkworm eggs from Philadelphia, which were kept in an upper room, without a fire, and hatched early in April: they were fed the first week on lettuce, afterwards on the leaves of the white and native mulberry tree, and came to maturity within from twenty-four to thirty days, and spun their cocoons before the 12th of May. On the last days of May, and first of June, the moths came out and laid their eggs on paper, which was loosely rolled up, and placed in an upper room. Within eight or ten days from the time the eggs were laid, they began to hatch, and, before the 15th of June, nearly one-twentieth part had hatched; the worms were healthy, fed well, grew more rapidly, and came to maturity in a few days less time than the first crop. They wound their cocoons in the first days of July; on the last of that month, and first of August, the moths came forth, and laid their eggs, which were placed in the same room as the first eggs. In about the same length of time, they also began to hatch, and all the worms came out between the 12th and 18th of August. They came to maturity, and spun their cocoons, in somewhat less time than the first, viz. before the middle of September:* the moths came forth, and laid their eggs the first days of October."

On the subject of these repeated productions, Mr. Millington says: "I feel confident that, in most parts of the Union, the climate will admit of more than one crop of silkworms being raised in the course of a year, as in Asia. Our weather is equally favorable for their health, for more than five months in the year, and if the leaves of our mulberry trees are frequently taken from them, they will continue to put out fresh leaves for the same length of time. Between the three successive crops which I raised the past summer, there were two intervals, each long enough to have raised other crops, when the weather was as favorable for their growth, and the mulberry trees were putting out leaves as luxuriantly as at any time during the summer. These intervals were from the 12th May to the 12th June; and from the 10th July to the 12th August, each long enough to have raised a crop of silkworms which would have made five crops. I am convinced, from the produce of the crops, that when five crops are raised the same year, the second, third, and fourth, will spin the largest and best cocoons. Our middle summer months are not too warm for such worms as are hatched out in, and constantly live in this warm temperature: but the first and last crops will be more apt to experience frequent changes in the weather, and will be more liable to be injured by both heat and cold.

"I do not doubt but that the following plan will effect the object of rearing successive crops: The eggs for the first crop, must be kept over winter, and be hatched, in the usual manner, about the middle of April. If the mulberry leaves are small, they may be fed a part of the time on lettuce; they will come to maturity, and wind their cocoons, within thirty days. The eggs for the second crop must also be kept over winter, and their hatching retarded in the spring, by

* Owing, doubtless, to the increased heat of the weather.

keeping them in a very cold cellar, or ice-house, until within five or six days of the time in which this crop will be wanted, when, by bringing these eggs into the room, they will readily hatch: or the eggs for this second crop may be provided by forcing a few worms to hatch about the middle of March, in a warm room, and by feeding them on lettuce until the mulberry trees will furnish leaves. These worms will grow slowly, and probably will not spin much silk; but if they are kept in a warm room, they will be healthy; and will furnish eggs which may be used for the second or following crop. The eggs for the third, fourth, and fifth crops of worms, will be furnished by the first and second crop of worms, or they also may be kept over winter, and their hatching retarded in the spring, by keeping them in an ice-house* until the worms are wanted.

"The eggs of the silkworm will bear a greater degree of heat the same season they are laid, without hatching, than is required to hatch them the following spring, By being chilled during the winter, they seem to acquire a greater sensibility to heat, and a greater disposition to hatch. When we wish to hatch them the same season they are laid, this process of nature may be somewhat imitated by keeping them in a cold cellar, from the time they are laid, until wanted to be hatched; this will facilitate their hatching; yet if the weather is not very warm, artificial heat may still be necessary, and a constant exposure to a temperature somewhere between eighty and one hundred degrees of Fahrenheit, in a moist atmosphere, will hatch them in five or six days.† The hatching of these eggs may also be facilitated, or rather, silkworm eggs may be procured, which will have a greater disposition to hatch the same season, by putting the cocoons which contain the insects in their pupa state, in a cellar where the temperature is at about sixty degrees, and by keeping them there until they change to moths and lay their eggs; these eggs, soon after they are laid, might be kept in a temperature still lower, until wanted to be hatched.

"That silkworm eggs, thus procured and kept, would have a greater disposition to hatch, I am convinced by the following late experiment. I had some eggs laid in June, when the thermometer ranged between ninety and ninety-six degrees; some laid in August, when the thermometer was between eighty-eight and ninety-four degrees; and some laid the first of October, when the thermometer was between fifty-eight and sixty-five. These three parcels of eggs I exposed to a temperature of between sixty-six and seventy-two, on the 10th of October, and before the 20th, that parcel of eggs which were laid in October, when the weather was cool, hatched out; but the two first parcels, which were laid in warmer weather, did not hatch.

I have supposed that the whole of each crop of worms will be hatched at the same, and will all come to their full growth at the same time, and each crop will occupy the shelves about one month. In this case, (from their diminutive size,) enough of these worms to fill all the

* The eggs must not freeze.

† The propriety of this treatment is, however, questionable. See p. 64, on overheating eggs.

shelves when at their full growth, will fill only a small part; the first two weeks, therefore, where the object is to keep the shelves constantly filled with the greatest possible quantity of worms, something may be gained by having each crop hatched out on several different days, and each day's hatching kept by itself. Under this management, the hatching may be so arranged as to keep the shelves filled with worms of different ages, and of all sizes, which will enable the shelves to hold twice as many worms as they would otherwise admit of; and this management will also give the tenders constant and regular employment; every few days they will have some new cocoons of silk to remove from the shelves, and some young worms to put on to supply their places."

Remarks.—In the warm States, which abound with many unemployed hands, the foregoing plan may be put in execution. But the trouble attending it will probably cause few, if any, to attempt it. Confusion and injury would moreover ensue, from having young worms on the same shelves with the worms spinning their cocoons, (a time when they require to be kept perfectly quiet,) even were it practicable to accommodate both. Mr. M. has, however, demonstrated, that more than two crops of worms can be raised in those States where the heat continues long and steady.

"Messrs. Weiss and Youngman, of Bethlehem, Pennsylvania, raised two crops during the year 1825. The worms of the second crop appeared more vigorous and healthy than those of the first. They also produced larger cocoons, the silk of which was of a better quality."*

Two attempts, viz: in 1826 and 1827, to rear two crops of worms, by Messrs. Terhoeven, Philadelphia county, failed. The worms, from the eggs laid in the early part of the season, hatched, but they soon died.

CHAPTER III.

OF OTHER CATERPILLARS PRODUCING SILK.

The larva of the silk-moth is not the only insect which yields silk. Other insects produce the same substance, which, in point of strength, far exceeds that of the common silkworm. These insects are natives of India, and bear the names of Bughy or Tusseh,† and Arrindy‡ silkworms, and have been fully described, and figured in colors, by the late eminent naturalist, Dr. Roxburgh.|| Both exceed the common silkworm in size; the first especially; and the silk of which appears to be more valuable than that of the other kind. The Tusseh silk is

* Dr. Stout: letter to the Hon. C. Miner, of the House of Representatives.
† Phalæna Attacus Paphia, of Drury.
‡ Bombyx Cynthia.
|| Trans. Linnæan Soc. Lond. vol. 7.

found in such abundance in Bengal, and the adjoining provinces, as to have afforded the natives, from time immemorial, an ample supply of a most durable coarse silk, which is woven into a kind of cloth, called Tusseh doot'hies, and much worn. The caterpillar, when full grown, is about four inches in length, and bulky in proportion; its color is green, with a lateral stripe of yellow, edged with red; when ready to spin, they envelope themselves in two or three leaves of the Jujube tree,* the vegetable upon which they feed. These leaves form an exterior envelope, which serves as a basin to spin the cocoon in, which is then suspended, by a thick silk cord, from the branch of the tree. It remains nine months in the pupa or chrysalis state, and three months in that of the egg and caterpillar. The insect, when produced, expands to the breadth of five or six inches, and those of the female to eight inches. They immediately escape. The worms feed on the trees, and are watched day and night, to guard them against birds. The natives of India pretend that these worms cannot be domesticated. The durability of the silk woven from it, is astonishing.† The arrindy silkworm is the *Bombyx Cynthia* of the naturalists. It is peculiar to the interior of Bengal, and is reared in a domestic state, as the common silkworms. The food of the caterpillar consists entirely of the leaves of the common castor-oil plant.‡ It is about three inches long when full fed; the color pale green. The cocoon is white or yellowish, of a very soft and delicate texture, about two inches long, and three in circumference. The insect remains in the pupa state but twenty days. The filaments of the cocoon are so delicate, that it is impracticable to wind off the silk; it is therefore spun like cotton, and woven into a coarse kind of white cloth, apparently of a loose texture, but of incredible durability; the life of one person being seldom sufficient to wear out a garment made of it. The coverings of palanquins are made of this silk. Mr. Glass, British Army Surgeon, sent some of it to his friends in England, and, upon being shown to some silk manufacturers, they gave it as their opinion, that it could be made into shawls, equal to any received from India. Another species is called Jarroo, the cocoons of which are spun in the coldest month, viz: January; the silk is of a darker color. The males, when hatched, invariably fly away, but the females remain on the *asseen* trees, upon which the worms are placed to feed. These are not impregnated by the males bred along with them, which fly away; but, in ten or twelve hours, another flight of males arrives, and impregnate the females, which deposite their eggs on the branches. The natives are able to retain part of the Jarroo cocoons for seed, which

* Rhamnus Jujuba, L. or Byer of the Hindoos. They also feed on the leaves of the *asseen* tree; the *Terminalia alata Glabra* of Roxburgh.

† From a Chinese paper, on the culture of the Tusseh silk, which Mr. Huzard lent Mr. Latreille, he is convinced that the insects producing it were the wild silkworms of China; and he conjectures that a part of the silk stuffs which the ancients procured by their maritime commerce with India, was made from the silk produced by these insects. Regne animal, par Cuvier. Tome 3d, p. 564, Paris, 1817.

‡ Ricinus Palma Christi.

they hang out on the *asseen* trees, when the proper season for the moth arrives.

Du Halde* mentions that in the province of Chantong, there is found a species of silk in great quantities on trees and in the fields, which is spun and made into a stuff called Kient-chou. This silk is the production of little insects much like caterpillars, which do not spin cocoons, but very long threads; and, being driven about by the wind, hang upon the trees and bushes, and are gathered for use. The stuff is much coarser than that made of silk spun in houses. The worms are wild, and eat indifferently the leaves of the mulberry and other trees; they are of two kinds; one is much larger and blacker than the common silkworms, and are called Tsouen-Kien; the other, the Tyan-Kien, are much smaller. The silk of the first is of a reddish gray, that of the other is darker. The stuff made of these materials is between both colors; it is very close, does not fret, is very durable, washes like linen, and, when good, receives no damage by spots, even though oil be spilt on it. Dr. Robertson informs us, that the nature and productions of the wild silkworms are illustrated at greater length in the large collection of Memoirs† on China, and by Pere de Mailla, in his voluminous history of China.‡ It must have been these worms to which Virgil referred:

Velleraque ut foliis depectant tenuia seres.—*Georg. lib.* ii. 121.

It was to the same species of silk to which Pliny refers, when he mentions "the stuff made from a white downy substance, combed by the Seres from the leaves of trees, which differed from the wool-bearing trees (cotton) of the Island of Tylos in the Persian gulf."

Don Luis Nee observed on certain trees growing in Chilpancingo, Tixtala, &c., in South America, ovate nests of caterpillars, eight inches long, which the inhabitants manufacture into stockings and handkerchiefs.§ Great numbers of similar nests, of a dense tissue, resembling Chinese paper, of a brilliant whiteness, and formed of distinct and separable layers, the interior being the thinnest, and very transparent, were observed by Humboldt, in the province of Mechoacan, and the mountains of Santarosa, at a height of 10,500 feet above the level of the sea, upon various trees.|| The silk of these nests, which are the work of social caterpillars, was an object of commerce, even in the time of Montezuma; and the ancient Mexicans pasted together the interior layers, which may be written upon without prepa-

* History of China, vol. 2d, p. 359, Lond. 1741.

† Histoire des Sciences, les Arts, &c. des Chinois, tom. 2d, p. 575, &c.

‡ Tom. 13, p. 434, Robertson's disquisition concerning ancient India, note 33. Mr. Delalauze, the author of the essay on silkworms, in the "Cours d'Agriculture," by Rosier, mentions these Chinese worms, on the authority of Madam Lottin, who published a treatise on silkworms in Paris, in the year 1757; but takes no notice of Du Halde, although his history of China was published in France nearly twenty years before.

§ Annals of Botany, 2d, p. 104.

|| Political Essay on New Spain, vol. 3d, p. 59. They were 7 to 7½ inches long by 3¾ broad.

ration, to form a white glossy pasteboard. Handkerchiefs are still manufactured of it in the Intendancy of Oaxaca.

In the first volume of the Transactions of the American Philosophical Society of Philadelphia, is a paper by the late Moses Bartram, of Philadelphia, in which are recorded some experiments in propagating caterpillars from cocoons, found on the black haw, alder, and wild crab tree. He did not attempt to reel silk from either those he found wild, or from others which were formed in his own house: but subsequent and recent trials to produce a continuous thread from various native cocoons, have repeatedly proved abortive. The Rev. Mr. Pullein, of England, has indeed recorded,* that from the pod of the moth called "isinglass" by Madam Merian, and which he received from Pennsylvania, he produced a thread of twenty single fibres, which bore a weight of fifteen and a half ounces; while the thread of the common silkworm, of the same size, always broke with fifteen ounces. Mr. Abbot also says, that he had heard of the cocoons of the Bombyx Cecropia having been carded, spun, and made into stockings, which washed like linen; but that the insect will not bear confinement. It feeds on the leaves of the cherry tree.† On the outside of the cocoon, the web is coarse; the inside is covered with silk like a silkworm cocoon.

Miss Rhodes could not succeed in winding any silk from one of the native cocoons, which she received from South Carolina.‡

Madam Humbert§ had some coarse strong silk from cocoons of native wild worms in Louisiana, but, although the cocoons were larger than those of the foreign worms, yet the quantity of silk was less than that produced by the latter. For the above reasons it is clear that they are unworthy of attention.

CHAPTER IV.

OF MULBERRY TREES.

Botanists have, hitherto, discovered only one native species of mulberry tree in North America, viz. the red, (*morus rubra*,) which has an extensive range. Michaux assigns the same limits north to it as to the majestic and beautiful tulip tree, (*liriodendron tulipifera*,) viz. the northern extremity of Lake Champlain; but it also grows in Massachusetts. Southward and westward, it abounds in all the States, and has been recently found as far west as the lower part of the river Canadian.‖ The leaves of the red mulberry tree are large, generally

* Trans. Royal Soc. Lond. 1759, p. 54.

† The natural history of the rarer Lepidopterous insects of Georgia, by John Abbott, 2 vols. 4to. Lond. 1797, plate 45.

‡ Anderson's Bee, Edin. vol. 11, p. 173.

§ Du Pratt's Hist. Louisiana, p. 187.

‖ Found by Dr. James, of the U. S. Army. Annals of the Lyceum, New York, vol. 2d, p. 246.

entire, but sometimes divided into two or three lobes, rounded, heart shaped, and denticulated, of a dark green color, thick texture, rough and uneven surface. The sexes are usually separate, though sometimes they are found upon the same tree. The fruit is of a deep red color, an oblong shape, and of an agreeable, acidulous sugary taste; it is composed of the union of a great number of small berries, each of which contains a minute seed. The tree often exceeds sixty feet in height, and two feet in diameter. The wood is of a yellowish hue, approaching to lemon color, fine grained and compact, and when perfectly seasoned, is as durable as the white locust,* on which account it is highly esteemed for posts, and, by ship and boat builders, for the upper and lower frames of vessels, knees, and floor timbers, and the ribs of boats. In Tennessee, and probably in the other Western States, when a native forest is cut down, if the land be enclosed, a growth of red mulberry trees, it is said, soon takes its place.†

There are several varieties in the red mulberry tree, depending on the leaves and fruit:

1.	Leaves all orbiculated, (round.)		
2.	do	deeply lobed.	
3.	do	with three short lobes.	
4.	Fruit, berries nearly white.		
5.	do	do	bluish purple.
6.	do	do	red and long.
7.	do	do	blackish red.

Mr. C. C. Robin, a French traveller, mentions a species with leaves similar to the red mulberry in shape, but rough and shining on the upper surface, and downy underneath, with white fruit, and growing in Louisiana. Travels in L. &c. Paris, vol. 3d, p. 379. Mr. Darby notices one which he calls M. *scabra*, or Spanish mulberry, which is found in Opelousas. *Description of Louisiana.* Both these may be varieties of the morus rubra.

That the leaves of the native red mulberry tree agree perfectly with silkworms, and yield very good silk, is a fact so well established by the experience of more than a century, that, to doubt it, would amount to an absurdity. It appears, however, that the leaves do not suit the constitution of French worms, and the author,‡ of the experiment, which he made to satisfy himself, on this point, therefore decides

* *Robinia pseudo-acacia.*

† The fact of the spontaneous succession of forest trees of a different kind from those which had formerly grown on the same land, when the first growth has been cut off or burnt, was known to the people of the United States from their early settlement; but when the enterprising M'Kensie (*a*) mentioned it, the truth of his statement was denied by the Edinburgh reviewer (*b*) of his work; although a similar fact had been, ten years before, noticed by Mr. Cartwright, in his Journal of a residence in Labrador, Lon. 1792, vol. 3, p. 225. For some interesting facts on this subject, see the papers of Judge Peters, Mr. Adlum, and others, in the 2d vol of the Memoirs of the Philadelphia Society for promoting Agriculture.

‡ Mr. Delongchamps: Essai, sur l'Histoire des Muriers; et des Vers a Soie. Paris, 1824

(*a*) Voyage from Montreal to the Frozen and Pacific Oceans, in the years 1789 and 1793. London, 1801
(*b*) Vol. 1. 1802.

against the fitness of the tree for the food of the insects. He acknowledges that they eat the leaves of both the white and red species indiscriminately, when mixed, without evincing a preference for either, and that when they were placed in separate parcels within half an inch of each other, they never left the latter until they were all devoured. A similar remark as to their promiscuous feeding on both species of leaves, had been previously and long since made in Louisiana, by Madam Humbert,* a native of France, and was recently confirmed by Mr. Seth Millington,† of Missouri. Madam H. adds, that the silk from the worms fed on the leaves of the native tree, was equally good as that produced by the white species, and that both "were stronger and finer than that of France."

From the character of the leaves and fruit of a native mulberry tree growing in Washita,‡ there is reason to believe that it is a different species from the *Morus rubra.*

The leaves received, are three-lobed, three-nerved, unequally serrated; base subcordate entire; lobes, ovate oblong acute, or acuminate; sinuses broad, with large interjected acute teeth. Both surfaces rough.

The leaves are larger than the red species: upper lobes more ovate, with base narrowed; no pubescence beneath; lateral lobes narrower than the middle. Teeth of the sinuses, sometimes entire, sometimes with a few unequal teeth on the side. Upper sinuses broader than the lower.

OF THE WHITE MULBERRY TREE.

The white mulberry tree, Morus alba, is a native of Asia, and was introduced into Italy by some of the survivers of the last crusade. Olivier de Serres relates, that the French who accompanied Charles the Eighth, in his invasion of Italy, in 1494, struck with the abundance of the trees in that country, and with the profit derived from the culture of silk, determined to introduce it into France. This was done by Guy Pape, of Saint Auban, after the peace, who planted it near Montelimart. In 1802, Faujas de Saint Fond saw the original tree, around which Mr. Lachaux, to evince his respect for this monument of agriculture, and parent of all the white mulberry trees in France, had built a wall. There are several species of this tree, and numerous varieties, the result of cultivation, soil, climate, and the play of nature. The forms of the leaves are extremely variable. Mr. Audibert,§ an experienced cultivator in France, says, "that the same tree will have leaves divided into several lobes, when young; and, when it becomes old, they will be entire. Others have the second crop of leaves differently formed from the first; some again have entire leaves in the spring, and lobed leaves in the autumn. Hence, it is extremely difficult to assign positive characters to the different varieties, particularly when they show no diversity in appearance, except in the shapes of the leaves."

* Du Pratt's Hist. of Louisiana, p. 187.
† Answer to the silk circular.
‡ The leaves were sent by Judge Bry, to the Secretary of the Treasury.
§ Essai, &c. p. 21.

On the culture of the White Mulberry Tree.

All the practical writers on this subject, agree that the proper soils for the mulberry tree are dry, sandy, or stony; the more stony the better, provided the roots of the trees can penetrate among them. The situation should be high: low, rich, and moist land, never produce nourishing leaves, however vigorously the tree may grow. They are always found to be too watery.

The modes of propagation are, 1, by seed; 2, grafting; 3, budding; 4, layers; 5, cuttings; 6, suckers.

1. The ripe fruit may be sown in drills in ground previously prepared; or the seeds may be washed out of the pulp, and mixed with an equal quantity of sand or fine mould, and then sown. They should be covered about a quarter or half an inch deep. The seeds will soon vegetate if the ground be rich, and will live through the winter, unless the cold should be unusually severe.* In that case, they should be covered with straw or long manure: in the course of the next season thin the plants, so that they may be a foot apart. Seeds intended to be sown in the spring, or to be kept, should be washed out: for they are apt to heat or mould if allowed to remain in the fruit. Every tiller of land knows the fertilizing effects of frost and snow; the land, therefore, destined for the spring sowing, should be dug or ploughed in the preceding autumn, left rough all winter, and harrowed or raked fine as soon as the season will permit, and the seed sown in drills. The young plants must be watered in dry weather, and weeds carefully kept down. Weeds will not only stint the growth of the plants, but cause diseases in them, which may affect the future vigor and health of the tree. When a year old, some of them will be fit to plant in nursery rows; the same plants may remain in the seed bed a second year, and then be transplanted; the plants at two feet distance from one another, that there may be room for cleansing and dressing the ground. At transplanting, cut off some of the roots, especially those that are ragged or decayed, and the tap root, to force out lateral roots; and also the tops, at six or seven inches from the ground. In France, they transplant just after the fall of the leaf in the autumn. When the plants in the nursery are sprung, strip off the side buds, and leave none but such as are necessary to form the head of the tree. The buds which are left, should be opposite to one another. If the plants in the nursery do not shoot well the first year, in the month of March following cut them over, about seven inches from the ground; this will make them grow briskly. They should also be watered with diluted barn-yard water.

When the plants are grown to the size of one inch in diameter, plant them out in the fields where they are to remain; make the holes six feet square, and dress the ground two feet round the plants; trim the roots, and press the earth on the roots as the holes are filled. During the first of planting out, leave all the buds which the young trees have pushed out on the top, till the following spring, when none

* A quantity of plants from seed thus treated, lived through the cold winter of 1825-6, in Philadelphia.

are to be left but three or four branches to form the head of the tree. The buds on these branches should be on the outside of them, that the shoots may describe a circle round the stem, and that the interior of the tree may be kept open; and as the buds come out, take off all those which appear upon the body of the tree. For several years after, every spring, open the heads of the trees when too thick of wood, and cut off any branch which crosses or takes the lead of the rest; leaving two buds on the outside of every trimmed branch. Count Verri,* an experienced cultivator of the mulberry tree, recommends to leave only two buds at the end of each branch—preferring those which are outside and opposite to each other—and when three buds appear together, to leave the middle one, which is always most vigorous, and to detach the two on each side of it. If the superior buds do not push well, the two next lower ones, only, must be left. Every farmer and nurseryman, knows the very great importance of dressing the ground round young trees, twice in the course of the year, and of planting stakes by them, to ensure an upright, straight growth, and to prevent their being shaken by wind, or levelled by storms.

2 and 3. Grafting and budding may be performed on the mulberry tree, in the modes usually adopted for other trees. So great is the prejudice in Italy in favor of grafting the mulberry trees, that Dandolo says, "even the hedge mulberry trees are grafted." The reason for this is, that the grafted tree yields more leaves than those produced from seed; but he decides, as will be hereafter seen, in favor of the latter. Nevertheless, as it may be wished to propagate a particular species, or variety of mulberry tree, the leaves of which are found to produce better silk than common, the process may be adopted which is generally preferred in France for grafting the mulberry and large chestnut, and is as follows:

A branch must be selected, sound, and of the growth of the preceding year, when possible, and while the sap is running: this is to be cut off some inches from the trunk, or further off, according to its strength or size. The annexed cut represents a piece of a branch, separated; but we must suppose it attached to the trunk. From the point A to the point B, the bark is to be slit in strips by the edge of a pruning knife; and these strips are to be gently detached from the wood, (without bruising them,) as is seen at E. While an assistant is engaged in this operation, another prepares a cylinder, or tube, C; having a bud, D, or several buds, and of equal diameter to that of the wood, A, when barked. Then, without loss of time, it is to be slid upon the wood, until its lower extremity touches the basis of the strips. If the cylinder applied to the wood is proportioned to it, and if it covers all the wood, and unites exactly with it, the strips are to be cut off below the cylinder, by a circular cut; and after having made the two barks join,

* L'Art de Cultiver Les Muriers. A Lyon, p. 60. 1826.

the united parts are to be covered with a mixture of turpentine, wax, and rosin, spread on thin leather.* Every boy is acquainted with the mode of procuring a pipe to make a whistle from a willow, by cutting off a branch, and gently beating the bark, until it loosens from the wood: the mulberry pipe is to be procured in the same manner.

When it is difficult to find a branch, the bark of which will fit exactly the branch which is cut in strips, the following expedient may be adopted: If it be too narrow, a branch must be slit longitudinally, on the side opposite to the bud, and the cylinder being taken off, is to be applied to the wood; then a part of a strip is to be raised, that corresponds to the deficiency in the cylinder, and must be divided in its whole length, of a breadth wanting in the ring, so that this division fills the vacant space: Finally, raise up and surround it with the strips, as already directed. If the bark cylinder be too large, cut it to the diameter of the wood, then fit the edges as nearly as possible, and cover them with the strips.†

The propagation by budding would seem to demand particular attention, from the success attending the operation by Mr. Millington, of Missouri, who says: "With a view to increase my little stock of white mulberry trees, I have, this past summer, (1826,) budded them on our native stocks: these buds took well; and such as I put in before the middle of July, were forced out immediately, by cutting off the stocks above the buds. Some of these buds have already (October 27,) made limbs more than two feet long. The buds I have put in since the middle of July, I shall not attempt to force out until next spring. I consider this the best mode to manage the buds. Budding is more expeditious and surer than engrafting; and when it fails, does not injure the stock so much as this mode. Native stocks to engraft or bud on, can be procured with the greatest ease; and the trees thus raised, would not be liable to be diseased in their roots, as foreign trees; and these engrafted or budded trees would grow much faster, and furnish leaves much sooner, and of a larger size and better quality. This will not be doubted by those who have observed how much faster an engrafted tree grows, and how much larger its leaves are, than those of a seedling tree."

4. Laying.—The propagation of trees by layers is only necessary for such trees as do not grow freely by cuttings, or of which seeds cannot be easily procured; but as neither of these reasons apply to the mulberry tree, no directions on the subject are necessary. Those who wish information on it, may consult McMahon's American Gardener's Calendar, a work which should be in the possession of every country gentleman in the United States.

5. Cuttings.—These should be taken from perpendicular shoots,

* This composition was preferred by an eminent farmer and horticulturist, the late Joseph Cooper, of New Jersey, as it is not liable to contract and fall off by the heat of summer, or to be washed off by rain—accidents which often happen to the masses of clay put round grafts.

† Memoirs of Philadelphia Society for Promoting Agriculture, vol. 3; from "Rosier's Cours Complet d' Agric." vol. 5, p. 324.

and particularly those that terminate branches:* these will certainly produce straight and handsome trees; while cuttings taken from horizontal branches, will ever have an inclination to grow in a spreading manner. The cuttings should be of the last summer's shoots, and from six to fifteen inches in length. Plant them in rows, in shady borders, early in the spring, and about two-thirds their length in the ground; close the earth well about them, and in dry weather let them be watered. After a year, they may be transplanted into open nursery rows, if well rooted.

6. Suckers.—These may be separated from the parent plants early in the spring, each with some roots, and planted either in nursery rows for a year or two, or the largest in the place intended for them permanently. It is essential for the success and quick growth of young plants, that the ground around them should be fine, so that the tender roots may not be obstructed in their progress. SLUGS and SNAILS are very destructive to mulberry plants, and will eat down numbers of them in one night, and, in a moist season, will ruin a nursery, if not prevented. To prevent their depredations, surround the beds with soot, hot lime, or ashes, sprinkling a fresh parcel when they have been wet with rain; but no soot should be put on the beds, being too acrid for the plants. If the insects appear, destroy them after sunset. Mr. Pullein† says the best defence against them is a hair rope, which should be trimmed so as to be made as bristly as possible; this being pinned to the ground round the border of the bed, will so prick their tender skins that they would not venture to cross it.

In order to secure early food for silkworms, the cultivator should plant a hedge of mulberry trees, or a few young trees in a warm situation. In the spring they should be covered with straw, or any other way, at night, to prevent injury from frost. As the white mulberry tree grows readily, with proper care,‡ they may be easily multiplied. They may be planted along the fences of a farm, and if the branches be wattled through the rails, they will form an impenetrable hedge, and the fence will never require renewing. A great advantage will attend such a hedge, viz: the ease with which the leaves can be obtained: the avoidance of falls by young persons from large trees, is another consideration in favor of propagating mulberry hedges. This accident may also be prevented by annually pruning the trees, and restraining their upright growth to the extent they are commonly permitted to attain. The quantity and quality of the leaves will also be thus greatly increased. Practical writers, particularly Sauvage, dwell

* These are termed cock-shoots by gardeners.

† On the culture of silk. London, 1758, p. 32.

‡ A number of these trees, which were planted by the late Joseph Cooper, of New Jersey, measured from twenty to twenty-six inches in diameter, after standing twenty-three years.—Mem. Phila. Soc. for Prom. Agric. vol. 5, p. 190. The MS. journal, left by the Rev. Mr. Baltzius, of the German settlement of Ebenezer, Georgia, under date of March, 1757, mentions, that two trees in front of the Parsonage, which had been planted ten years before, measured three feet eight inches in circumference. He saw another five years old, which measured two feet round the trunk.

upon the importance of annually pruning trees, for these reasons; and a gentleman, recently returned from an extensive tour through Europe and the East, states, that the cultivators of silk, particularly in Syria, were unanimous as to the superiority of the silk produced by worms fed on the leaves of trees annually pruned, over that made by worms nourished by trees, the growth of which was unrestrained. The American cultivator is urged to attend to this hint, whether he feeds silkworms on the native or foreign tree.

The white mulberry trees which have been planted in Massachusetts and New Hampshire, grow well, and are not injured by frost.* They have not yet been introduced into Maine, but there is no reason to doubt their flourishing in that State, and also in Vermont. Should, however, the cold prove injurious to them, the Tartarian mulberry, which is cultivated for silkworms in the silk-rearing province of Zacsyn, in Russia, might be easily introduced.†

There are several varieties of the white mulberry tree, two of which have white berries, one red, and the other black.‡ There are two varieties in the leaf; one has a leaf deeply indented, and supposed to contain little nourishment; the leaf of the other is larger, and not much indented, nor lobed. The common grafted mulberry is a variety of the first of these two, and itself comprises the following varieties: 1st, with white berries; 2d, with red berries; 3d, with black berries; 4th, with a large leaf, called the mulberry of Tuscany; 5th, with a middle-sized leaf, dark green, called *faglia giazzola;* 6th, with a small leaf, of a dark color, rather thick, called double leaf, more difficult to pick, and the best calculated for silkworms.§ Besides these, there are numerous other species and varieties in Europe, the result of cultivation; but the detail of their names, and their description, would be useless. A late French writer, and a practical man,‖ after having taken up several pages of his work in describing them, decides in favor of those called Colombasse and Colombassette, as being favorable to the health of the silkworms, and as yielding the greatest quantity and the best quality of silk. The leaves are small, thin, light, and silky. The fruit, when at full maturity, is yellowish, and very large. He also approves of the species called the rose mulberry; the leaves of which are larger, and of a deeper green than the preceding species: the fruit is reddish, and as large as that of the other species.¶

* Answers to the silk circular.

† The white mulberry tree stands the winter in Sweden—a country quite as cold, in the winter, as Maine; and also that of Scotland.—Anderson's Bee, Edinb. vol. 18, p. 82. At Pekin, in China, it also flourishes, although the thermometer descends, almost every winter, to 20 deg. below 0.—*ib.*

‡ In New Jersey, there is a white mulberry tree with purple fruit.

§ Dandolo, p. 30.

‖ Essai sur l'Histoire, &c. p. 23.

¶ Mr. William Prince, of Flushing, Long Island, has imported from Europe, and has for sale, several of the most approved varieties of the white mulberry tree. A valuable addition to the stock of mulberry trees already in the country, has been recently made by Mr. F. Dusar, of Philadelphia, who opened a subscription for the purpose, and imported 400 young trees and 1000 plants from the South of France The name of the species was not mentioned by his correspondent.

There are five different substances in the mulberry leaves: 1st, The solid or fibrous substance: 2d, The coloring matter: 3d, Water: 4th, The saccharine substance: 5th, The resinous substance.

The saccharine matter is that which nourishes the insect, and forms its animal substance. The resinous substance is that which, separating gradually from the leaf, attracted by the animal* organization, fills the two silk vessels. According to the different proportions of the elements which compose the leaf, it follows, that cases may occur, in which a greater weight of leaf may yield less that is useful to the silkworm, as well for its nourishment as with respect to the quantity of silk obtained from the animal. Thus the leaf of the black mulberry (a native of Europe,) produces abundant silk, and strong, but coarse. The leaves of white mulberry trees, in high lands, exposed to cold dry winds, and in a light soil, produce a large quantity of strong silk, of the purest and finest quality. The leaf of the same tree, planted in damp situations, and in a stiff soil, produces less silk, and of a quality less pure and fine; but the chief cause which influences the fineness of the silk, is the degree of temperature in which the silkworm is reared, as, it is hoped, will be demonstrated in the course of this work.

According to Dandolo, the leaves of the broad-leaved white mulberry, are little nutritious. The next has a middle size leaf, thick, and of a dark green color. The best mulberry leaf, of any species, is that which is called the double leaf; it is small, not very succulent, of a dark green color, shining, and contains little water; which may be easily ascertained by drying some of them: the tree produces them in great abundance.

An old tree produces better leaves than young trees; as the tree grows older the leaves diminish in size.

The leaf of the wild [seedling] tree, contains the greatest proportion of both the nutritive and silky substances.† This opinion of Dandolo, in favor of the wild mulberry tree in preference to the grafted tree, as food for silkworms, is thus supported: "I have, says he, ascertained the following facts:

"1. That 14½ lbs. of wild mulberry leaves, will produce a pound and a half of cocoons, while 20¾ lbs. of the leaves of the grafted mulberry, are required to yield the same quantity.

"2. That 7½ lbs. of cocoons, proceeding from silkworms fed on leaves of wild mulberry, give about 14 oz. of very fine silk; whilst generally the same weight of silkworms, fed with leaves of the grafted mulberry, only yield eleven or twelve ounces of silk.

"3. That the silkworms fed on the wild leaves, are always brisker, and have better appetites.

The result is, that of taking two trees of equal age and vigor, the grafted tree yields 50 lbs. of leaves, and the wild tree only 30 lbs.; the weight of nutritious substance will be nearly equal in each."

"To this authority may be added that of Mr. Martleroy, an experienced cultivator in France, who found that silkworms, fed with the

* More correctly, decomposed, and assimilated by the worm.

† Dandolo, chap. 3.

leaves of the seedling mulberry tree, were more healthy, vigorous, and less subject to diseases, than those which are fed upon the leaves of the grafted trees.*

On the proportion of leaves to an acre or more of trees, and to silk produced from them. Cautions on picking leaves.

It is impossible to ascertain with any degree of tolerable accuracy, the quantity of leaves which an acre, or even a single mulberry tree will produce, owing to the operation of one or more of the numerous causes influencing their production: such as the particular species of trees; the greater or less care taken of them, in their early stages of growth; their position, and distance from one another, when planted out; the soil, and especially bad or injudicious pruning, or total neglect of this necessary measure. The estimates are, accordingly, very various. Mr. Fitch says, that one acre of full grown trees, set one and a half rods apart, will produce 40 lbs. of silk. One tree yielded food for worms, which gave four pounds of silk. Mr. Tufts confirms this calculation, but does not state the distance at which the trees stood from one another. Mr. Storrs says, that "a full grown tree will feed 6,000 worms, which will produce one and a half pounds of silk. An acre of trees will produce 60 lbs of raw silk in one season." Mr. R. Falley, now of Ohio, had 18 lbs. of silk from about 100 trees, part of which were young, in Massachusetts. In the year 1789, nearly four pounds were produced from seven trees, and one pound from eight trees, eight years old from the seed.† According to Dandolo, it is a certain fact, that, if silkworms are well managed, 21 lbs. of mulberry leaves will be sufficient to obtain a pound and a half of cocoons. Twenty pounds four ounces, will feed worms enough to produce a pound and a half of cocoons. In Dalmatia, he obtained one pound and a half of cocoons from 15 lbs. of leaves, which yielded one pound and a half of silk: ninety-seven pounds eight ounces of leaves, will produce seven and a half pounds of cocoons. Miss Rhodes could scarcely support 10,000 worms on the leaves of twelve large trees in England.‡ According to Lambruschini, 100 pounds of clean leaves will feed worms which will produce six pounds of silk.§ Dandolo has prescribed the proportions of leaves which will be required for five ounces, and one ounce of silkworms in their progressive stages, and lays down the weight of wood which will yield certain quantities of cocoons, produced by different species of the insect: as he writes from ample experience, his directions and conclusions may be safely relied on. [See chapter 13.] He recommends that the trees, when transplanted, be not stripped for three years, and to thin and prune the branches in the fourth year. In the fifth year, they may be stripped without danger; but he advises cultivators to permit a tree to rest one year after being stripped, in order to recover from the loss of its leaves.

* A Stephenson: Trans. Soc. Arts, Lond. vol. 43.
† Columbian Mag. Philad. Vol. 4, p. 61.
‡ Trans. Soc. Arts, London, vol. 4, p. 153.
§ Mem. Soc. Georgophiles, of Florence, vol. 4, p. 411.

This reasonable caution should be attended to, particularly with young trees; for leaves are considered as the lungs of a plant or tree, and mainly contribute, by the absorption of moisture, and the principle of vegetation from the atmosphere, to promote their growth and vigor. If deprived of these organs, annually, their growth will be greatly impeded.

The people of Connecticut and Massachusetts are of opinion, that trees only two years old, may be stripped without injury, provided the leaves near the ends of the branches are left,* and the main stem be not touched.† Count Verri recommends to pass the hands from the lower part of a branch to the top, and to pick the leaves in a bag, the mouth of which is to be kept open by a hoop, with a hook to suspend it. As practical rules, these directions are worth attention; but, in observing the last, it is essential that the leaves be not bruised.

The experiment was tried in Connecticut, of feeding worms with young mulberry plants, the seeds of which were sown broadcast, and the plants mown as wanted. The roots soon died. As the leaves of such plants contain so much less nourishment than those of old trees, the measure cannot be recommended, except for early food.

To form a Mulberry Hedge.

Choose grafted mulberry plants of one year old, and place them eighteen inches apart, in a furrow prepared some months before. To these may be added grafted plants of two years old, which have grown well, and which have been cut off to increase their vigor: but they must be separated from the others, to prevent irregularity in the hedge. Cut them at four or six inches from the ground, leaving two buds opposite each other: remove all the rest. In this way, the stalk has two vigorous branches the first year. In the following spring cut one of these two branches on the same side, at about one foot from the ground, so that each plant has a short and a long one. Bend, horizontally on the same side also, one after another, all the preserved branches, and fix them with willow-withs, so that they may form a line parallel to the earth, and leave untouched the entire branches. Experience has taught, that, if their extremities be cut, they grow slowly, and even die. At the commencement of the third year, the plants will have branches to form a hedge. Then cut them about two feet from the ground, but do not use the leaves. This plan has the following advantages:

1. The mulberry plants being grafted, and well arranged, and those of the first year being separated from those of the second, the hedge will grow with force and regularity.

2. The plants which have been cut down will push out near to the ground, and furnish numerous branches: When a plant dies, replace it by layers from an adjoining one; if a new plant be substituted it rarely succeeds. The leaves from the layers must not be pulled during the three first years.‡

*Mr. E. Williams, Mansfield, Conn.: letter to the writer. Z. Storrs, Esq. Conn.
† George A. Tufts, Esq. Mass.
‡ Count Verri, Sur les Muriers.

M. Bonafous* says, that the leaves of the paper mulberry tree agree perfectly well with silkworms in their fifth age. The character of this writer, and his great personal experience, entitle him to full confidence, and there can be no reason to doubt that the worms to which he gave these leaves eat them without injury; nevertheless, other silkworms were less fortunate. M. Deslongchamps† says, "that, of 100 silkworms to which he gave nothing but the leaves of the paper mulberry tree, 92 died; and the remaining eight, which survived the rest thirty-six days, would also certainly have died, if, at this time, he had not substituted the leaves of the white mulberry. This new food enabled them to live twenty and twenty-two days longer, and to spin their cocoons; but these were so small that eight of them did not weigh more than two ordinary cocoons." From the above statement, it appears that M. D. gave the leaves of the paper mulberry to young worms; whereas Mr. B. confines their use to the fifth age—a time when they have acquired their full growth, and their appetite is voracious. This variation in the treatment may readily account for the different results of the two cultivators.‡ The experiment with the paper mulberry leaves, in the fifth age, is worth trying with 50 or 100 worms; and, if made, it is requested that the result may be communicated to the public.

The black mulberry tree having been mentioned as suitable for the Southern States, it may be proper to say something on the subject. The leaves of this tree, it appears, are preferred in Spain,§ where superior silk is made. They are said to be much more nutritious than those of the white mulberry; but a late practical writer|| denies this position: for, in the year 1823, he fed some silkworms on the leaves of both these trees; and the cocoons of 100 of them which had eaten the black, weighed from two to three grains less, than others of another 100 worms which fed on the white. Mr. Nysten also says, that it is late in attaining its full growth, and difficult to propagate, either by grafting or by sowing the seeds. The leaves also come out full ten days later than the white. This is a serious objection, as early food for the worms is of primary importance: finally, the black is comparatively a tender plant. For these reasons, it cannot compete with the native red, or the foreign white mulberry tree.

* De l'Education des Vers a Soie, p. 11. Paris, 1824.

† Essai, &c. p. 91.

‡ Judge Bry, of Washita, says he tried to force his silkworms to eat the leaves of the paper mulberry, by starving them, and then offering the leaves: they bit them, and then left off eating. He believes they would have perished for food, had he not given them the leaves of the native mulberry, on which they fed with avidity.

§ Townsend's Travels in Spain. Swinburne's do.

|| Deslongchamps, p. 8.

CHAPTER V.

OF THE LABORATORY.

My laboratory, says Dandolo, is constructed to contain twenty ounces of eggs of silkworms; it is 30 feet wide, 77 long, 12 feet high, and, when reckoned to the top of the roof, 21 feet high. There are six rows of hurdles or wicker trays, about two feet six inches in width each, placed two and two, with four passages between them, each three feet wide. These hurdles or feeding frames may be made of cane, or basket work, to admit air from below, and must, in course, be proportioned to the number of worms. Those of Dandolo, for five ounces of eggs, are from 29 to 37 inches in breadth, and from 18 to 24 feet in length, and of equal sizes, that, when put above one another, they may not extend out irregularly. They are covered with paper to hold the worms. On the ledges or borders, may be painted the number of square feet contained on the surface; for instance, supposing the frame to be 20 feet long, and three feet wide, the number to inscribe would be "60 square feet." Posts are driven in between the trays, and strips of wood are fastened to the posts horizontally, to support the trays, between which there is a space of five inches and a half, to allow the air to pass freely.*

There are 13 unglazed windows, with Venetian shutters outside, and paper window frames inside; under each window, near the floor, ventilators, or square apertures of about 13 inches, that they may be closed by a neatly fitted sliding panel, so as to permit the air to circulate, and blow over the whole floor. When the air is not wanted, the paper frames may be closed. The Venetian shutters may be opened or shut, at will. When the air is still, and the temperature of the interior and exterior is nearly equal, all the window frames may be opened, and the Venetian shutters must be closed.

There are eight ventilators, in two lines, in the floor and in the ceiling, placed perpendicularly, opposite to one another, in the centre of the passages between the hurdles or trays. They have sliding panels made of thick glass, to close them, and to admit light from above. As the air of the floor ventilators ascends, and that of the ceiling ventilators descends, it must pass through the trays. There are, also, other six ventilators, made in the floor, to communicate with the rooms beneath. Three of the thirteen windows are at the end of the house; and at the opposite end are three doors, constructed so as to admit more or less air, as may be required. These doors open into another hall, 36 feet long and 30 wide, which forms a continuation of the large laboratory, and contains hurdles sufficiently raised to facilitate the care of the worms. In this hall, there are six windows, and six ventilators under them, nearly on a level with the floor, and also four ventilators in the ceiling. There are six fire-places in the great laboratory, one in each angle, and one on each side of the centre, and a large stove in the middle; glass oil burners, that give no smoke, are used to give light at night. Between the hall and the great laboratory,

* The mode in which the trays are arranged, is seen in plate 1, fig. 2d.

there is a small room, having two large doors, the one communicating with the laboratory, the other with the hall. In the centre of the floor, there is a large square opening, which communicates with the lower part of the building. This is closed with a wooden folding door; this aperture is used for throwing down the litter and rubbish of the laboratory, and for admitting mulberry leaves, which can be drawn up by a hand-pulley. Such is the construction of his laboratory, in which he places the worms after their third casting or moulting.

The above particular description of a very large laboratory, will be valuable to those who may hereafter engage in the business upon an extensive scale. It will be seen that the great objects aimed at, are convenience, the preservation of a proper temperature, and the free circulation of the air in the department; and the American cultivator must attend to these, as *cardinal points*, whatever may be the dimensions of the building or apartment in which the worms are reared.

All buildings are proper for receiving the silkworms, provided that, in proportion to their sizes, there be one or more fire-places, two or more ventilators in the ceiling, on a level with the floor, and one or more windows, by which light may be admitted, and yet not sunshine.

In the United States, the house erected expressly for the purpose of rearing silkworms, should be placed in the coolest and most airy situation attainable, and in the shade of trees, if possible, because it is always in our power to increase the heat of the apartment, when necessary, by means of a stove or open fire-place; but it is not so easy to guard against a sudden increase of heat in the weather, and which may nearly defeat the labors of the season, if it should occur in the fifth age, when the worms are nearly done eating, as will be seen hereafter.

The apparatus of the Rev. Mr. Swayne* is to be recommended, on account of the small space occupied by it, the neatness in which it enables persons using it to keep the apartment, and the ease with which the caterpillars can be fed, and their litter removed. It is particularly valuable to those who are restrained in room.

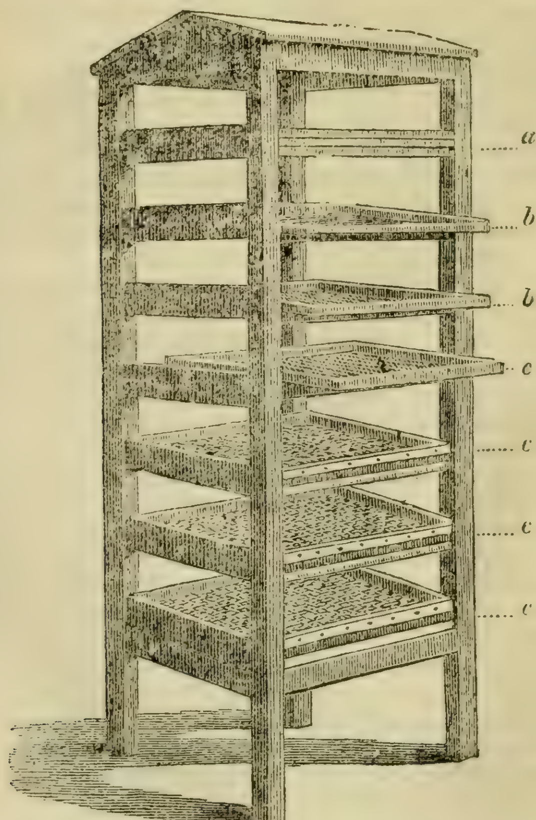
"This apparatus consists of a wooden frame, four feet two inches high, each side sixteen inches and a half wide, divided into eight partitions, by small pieces of wood, which form grooves, in which the slides run, and are thus easily thrust in or drawn out of the frame. The upper slide (*a*) is of paper only, and designed to receive the worms as soon as hatched; the two next, *b b*, are of catgut, the threads about one tenth of an inch distant from one another; these are for the insects, when a little advanced in size; the four lower ones, marked *c*, are of wicker work, the openings through which the dung is to fall being about a quarter of an inch square. Under each of these, as well as under those of catgut, are slides made of paper, to prevent the dung of the worms falling on those feeding below them. Mr. Swayne afterwards found that netting may be substituted with advantage, in the room of wicker bottoms. The meshes of the netting were about half an inch square.

* Trans. Soc. Arts, London, vol. 7, p. 148.

"The caterpillars are to be kept in the second and third drawers, until their dung and litter do not readily fall through, and then to be removed to the drawers with wicker bottoms, and fed thereon, till they show symptoms of being about to spin. Each wicker drawer will afford sufficient room for five hundred worms, when grown to their full size."

In order to give room for an increased stock of caterpillars, spare drawers should be made to fit the three upper apartments with wicker bottoms, (or, in preference, with bottoms of split rattans,) which may be used for full grown worms. The annexed cut will give an accurate idea of Mr. Swayne's apparatus.

The shelves of the feeding frames of Messrs. Terhoeven, of Philadelphia county, are four feet square, and are fixed to upright posts; they have two sets in one room, with passages between and around them. This size enables a person to reach any part of them. Over the shelves, are frames, placed on cleets, and filled with split rattans, at proper distances, to permit the litter to fall through.*



* See explanation of the plates. Plate 2d, fig. 3.

CHAPTER VI.

THE ART OF REARING SILKWORMS.

Of the care necessary previously to the hatching of the Silkworm—five ounces.

The first thing necessary to commence the operations of the year, is to detach the eggs of the silkworm from the cloths upon which they were deposited, and to prepare them for hatching.*

In past times, the cultivators imagined that the silkworm might be hatched at random, and spontaneously; and that, if it were necessary to make an artificial climate, it was enough to use the heat of beds, or the natural heat of the body, or the kitchen fire, &c. and similar means.† It is now allowed that these methods, at best uncertain, are often pernicious to the insect. However, since luxury has invented the hot-house, to enable us by an artificial atmosphere to raise exotics, it was surely natural to apply this invention to the improvement of the cultivation of silkworms; and yet it is but very lately that this application of the invention has been thought of, which enables us in a few days to hatch, with ease and certainty, any given quantity of silkworms, and rear them favorably.

It is proposed to state, in this chapter, the care which the eggs require, to prepare them for the favorable developement of the worm, and the care necessary to fix and continue the requisite degree of temperature. We shall thus treat of,

First. The preliminary preparation of the eggs.

Second. Of the necessity of fixing, by the thermometer, the temperature calculated to favor the hatching of the eggs, and the rearing of the silkworm.

Third. Of the hot-house, or stove-room, in which they must be hatched.

Fourth. Of the hatching.

I. We suppose the eggs to be good, and well preserved, as shall be indicated in the course of this work.

When the mulberry leaves are about to open, the cloths upon which the eggs are fastened, should be put into a pail of water, steeped up and down, that they may be thoroughly soaked, for nearly six minutes, which will be sufficient to dissolve the gummy substance by which the eggs are stuck to the cloth. There must be, in this room, tables

* These directions to scrape off the eggs from the cloth or paper upon which they were laid by the moth, are given in the European books on silkworms, and yet would seem to be unnecessary. Careful observation of the insects when hatching, has satisfied the writer that they even find less difficulty in leaving their shells when they remained fixed, than when they were detached. In this opinion he is sustained by two persons familiar with the rearing of silkworms.

† This is the general practice, also, in the United States; but it is to be hoped that cultivators of silkworms will be convinced, after reading this Manual, of the greater advantages attending the mode pursued and recommended by Count Dandolo.

proportioned to the size of the cloths. The six minutes elapsed, the cloths must be taken out, and the water allowed to drip from them, by holding them up for two or three minutes. They should then be spread upon the tables. The cloth should be kept well stretched, while the eggs are separated from the cloth with a scraper. The scraper should not be too sharp, for fear of cutting the eggs; neither too blunt, lest it should crush them. The eggs do not stick fast on wet linen.

When a good quantity of the eggs has been scraped off, they should be put into a basin; and this is repeated till all the eggs are scraped off, and put into the same basin. Water should then be poured upon the eggs, and they should be lightly washed, to separate them from one another. The water will be very dirty, as the eggs are always more or less soiled with the matter deposited by the moth. On the surface of the water will be seen floating the shells of a few eggs that have already cast their worms; also, many yellow eggs, which are not impregnated; and others, which, without being of that color, are very light. All these that float should be skimmed off directly. If the eggs are collected in an unfavorable season, particularly during cold weather, many yellow eggs, and even reddish ones, will sink to the bottom, although they are not impregnated. The water having been well stirred, it should be poured into a sieve, or upon some cloths, to drain off the eggs.

Should the rooms have brick floors, the cloth may be spread on the bricks and changed every five hours. Bricks dry the eggs by absorbing the moisture more quickly than any other substance. If the flooring is not of brick, hurdles of wicker work would be necessary, or basket work tables. In the course of two days, the eggs will generally be dry; they should then be put into plates, in layers of half the breadth of the finger, and left until it is needful to hatch them, being careful to preserve them from rats. It is essential to place them in a cool dry spot, in about from 46° to 59° Fahrenheit.*

II. The necessity of determining, by the thermometer, the suitable degree of heat for hatching and rearing the silkworm.

To produce, maintain, and regulate the degree of heat necessary in the space allotted to the hatching and progress of the silkworm, we must imitate the botanist in the management of the hot-house, and employ the thermometer. By this valuable instrument, we clearly see that it is of less importance that the silkworm should live in a temperature equal to the heat of its native climes, than that it should be preserved from violent transitions, and in a uniform temperature in its different ages. The thermometer, which cannot be affected by the caprice and will of man, is a certain method of attaining this important object of even temperature. For a large establishment, we shall re-

* It has been thought proper to retain the directions of Dandolo respecting the treatment of the eggs, preparatory to exposing them to heat, in order to hatch them, that comparative experiments may be made by them, and by the simple exposure of the eggs, while attached to cloths or paper, to the natural heat of the atmosphere, or that of a stove.

quire several well-constructed thermometers. Those made with quicksilver are always the most desirable, because the expansion and condensation of that metal are more exact than those of spirits of wine. The exterior sensations, and the disposition of the body, are often in opposition to the evidence of the thermometer. These instruments are therefore indispensable. The American cultivator of silkworms must not be alarmed at being told, that a thermometer is an indispensable instrument to his success: for ample experience has proved, that it is impossible to ensure it without one; and no one should attempt the business upon a large scale, and expect all the profit which will result from his labors and capital expended, unless the heat of the rooms is thus regulated. We all know the extreme atmospheric variations which often take place in the course of twenty-four hours, and these are highly injurious to silkworms. The whole, or the greater part, of a crop of worms, may be destroyed by a cold night; or, if not destroyed, their growth will be checked, the spinning of their cocoons be delayed, or rendered irregular and tedious; and they will also be of a less size than when the heat of the room has been regularly preserved. Thus, whether amusement or profit be the object, a thermometer is essential. The instrument, as will be hereafter seen, is also necessary to determine the proper degree of heat in the water in which the cocoons are to be put to wind off their silk.

It will be asked, do the people of Connecticut use thermometers? If not, do they not succeed without them? It is believed that they are not employed; and the consequences are, that millions of worms must die from the causes mentioned; that the profit is thus greatly diminished; and that many worms which do survive, become debilitated, spin small cocoons, and produce diminutive moths, and bad eggs. Hence the race is liable to degenerate. The people of Connecticut are not aware of the importance of a thermometer, or they would not be without one; and it only requires a single person among them to use one, and thus to demonstrate his greater success, to induce the practice to become general. The expense of a thermometer is trifling, and besides its utility in the business of rearing silkworms, it will be found a source of amusement to the owner and his family, throughout the year, by enabling them to ascertain the precise temperature of the seasons, and to judge of the comparative degrees of it in different years.

III. Of the hot-house, or room in which the silkworm should be hatched.

The first use of the thermometer should be in the hot-house, which is destined for the hatching of the eggs.

As it may be more favorable to our interests that the silkworm should be developed whenever we find it convenient, and as this insect must be reared in a season which, in our climates, has not the requisite warmth, it is therefore indispensable to create an artificial temperature suited to its progress. A small room or space should be preferred to a large one, as it is thus more easy to regulate the heat, and as it also saves fuel. Silkworms have been hatched in a small apart-

ment about twelve feet square, and capable of commodiously hatching not only ten, twenty, or thirty ounces of eggs, but even two hundred, if required. The small apartment must be particularly dry, and should contain all the necessary implements that may be wanted. The following details may be thought too minute, but this should not deter from giving every explanation deemed requisite in so important an art.

This small apartment should contain,

1st. A stove of moderate size, not made of iron, because the heat could not be regulated so accurately, but of thin bricks. It must stand out in the room. It is calculated to raise by degrees, slowly, and at will, with little wood, the temperature of the room.*

2d. Several boxes or trays, either made of thick pasteboard, if they are not large, but if large, of thin boards.† The size of these boxes should vary according to the quantity of eggs which are to be hatched. For an ounce of eggs, the space of about eight inches square is required. This may give an idea of the size and number of boxes that may be wanted, and we shall see hereafter how useful it is not to depart from this rule. The depth of the wooden trays or boxes, must, of course, be in proportion to their size. The boxes should all be distinctly numbered.

3d. Some wicker trays or tables.

These wicker trays should be placed horizontally against the wall, supported upon two pieces of wood fastened into the wall. When there are many of these wicker trays to be disposed of, they should be put one above another, with an interval of about twenty-two inches between them. These trays are for the purpose of holding the boxes in which the eggs are to be hatched. The boxes must be so disposed as to allow of easy inspection, that they may be examined as often as necessary. Care should be taken that the wicker trays be not too close.

4th. A flat spoon for stirring the eggs well.

5th. Several thermometers. They may be hung in various parts of the stove-room; or, still better, if laid by the side of the boxes, indicating the precise temperature of every part of the stove-room. For, it must be observed, the temperature varies in different parts of the room, particularly between the part next the stove and that nearest the door. This observation may be of use, as it may enable the cultivator either to force or retard the silkworms by some days; thus to hatch them as the mulberry leaf becomes fit for their food, which, in some positions and soils, is earlier than in others.

6th. A few light portable trays, for moving the small boxes which contain the young worms, or for moving them when they are more advanced. They should be made of thin board, about one foot in breadth, and long enough to fit across the width of the feeding frames or hurdles: the handle should be fixed in the centre, so as to allow of their

* The porcelain stoves imported from France, for about $ 10, or the tile stoves made at Bethlehem, Pennsylvania, would answer well. Turf, tanners' waste bark, or charcoal, are the materials for fuel.

† Shallow bandboxes are very convenient for a small quantity of eggs.

being carried firmly with one hand. They must be smoothly finished, that the silkworms may mount upon them without difficulty. The ledges around three sides ought to be about an half inch deep. The annexed cut will give a correct idea of their form.

7th. An air-hole or ventilator in the floor of the room with a sliding panel to open and close it, but which, in general, must be closed; it may be used to temper the heat, should it have exceeded the degrees which will be pointed out as necessary for bringing forth the silkworms. We have thus the means of making a gentle current of air between this air-hole and the door, to correct the excess of heat indicated by the thermometer.

8. A glazed window to light the stove-room. It is a vulgar error to imagine that light is not as necessary to the animation of the silkworm, as to that of every other living thing. The light does not incommode the silkworm, until it has reached its perfect state of moth, as we shall hereafter mention.

These are all that are required to furnish a stove-room. This room may be used for rearing the silkworms, as well as for hatching them; and being heated with little expense, might hatch silkworms for any number of persons.

IV. Of the hatching of the silkworm.

When the cultivator has observed the state of the vegetation in the mulberry leaf, and imagined it fitting to have his silkworms hatched in ten days, he will put the eggs in the boxes in the proper quantities. He must weigh them, and keep a register; in which he must note his observations upon the course and progress of the insects, and thus at once secure theory and practice; beginning by marking the day and hour upon which he sets the box in the stove-room, and also the number of the box; and, in short, every thing that may be worthy of notice. The wicker hurdles should have paper laid inside of them, and the distance before prescribed to be left between the boxes, is to prevent the silkworm from going from one to the other. If the temperature of the stove-room should not reach 64°, on the day fixed upon to put in the eggs, it is necessary to light a little fire, that it may rise to that degree, which ought to be continued during two days. If the thermometer indicate that the exterior air is above 64°, the shutters should be closed, and the door and the ventilator opened, to create a draught and cool the stove-room. The third day, the temperature should be raised to 66°, the fourth day to 68°, the fifth day to 71°, the sixth day to 73°, the seventh day to 75°, the eighth day to 77°, the ninth day to 80°, the tenth, eleventh, and twelfth days to 81°.*

* The propriety of attending to the gradual increase of heat in hatching the eggs, is so reasonable, and so conformable to all experience, that it cannot be too strongly insisted on. Great heat, suddenly applied and continued, never fails to push on the worms too fast, and to render them red when they first come out. The nearer the American cultivator is able to keep to the degrees of the thermometer which Dandolo has pointed out, the more certain will be his success.

The following are the signs of the speedy vivification of the silkworm:

The ash-gray color of the eggs grows bluish, then purplish; it then again grows gray, with a cast of yellow; and finally, of a dingy white.

If the eggs of silkworms belonging to different persons, are put into the same stove-room, great differences will be observable, not only in changes of color in the eggs, but also as to the period of hatching the worms. The insects of the eggs that have been preserved through the winter in an even and gentle temperature, and those of the eggs which have undergone maceration,* come forth in four or five days sooner, namely, at the 71st, 73d, or 75th, degree of temperature; whilst those that have been kept in a very cold atmosphere, appear some days later.

This stove imparts to each egg the degree of heat necessary to change the embryo it contains into the worm. When the eggs have been kept in a certain degree of warmth, it requires less stove-heat to develope the silkworm. This is so true, and so worthy of notice, that we find, if, in the winter, the eggs have been kept in an atmosphere of 55° or 59°, or heaped together, they spontaneously come forth, or without the aid of the stove, when the room is but slightly warmed, and before the mulberry tree has given any sign of vegetation. In this case, these worms must be thrown away, unless other food is at hand upon which they can be sustained for a time. This circumstance is, therefore, of essential consequence, and should be noted to prevent its occurrence. A little delay in the hatching of the worms is no loss; whereas it may be a very serious loss, if we anticipate, by a few days, the proper period of hatching. To backen them, when very near the time of coming forth, by altering the temperature, injures them materially. To prevent the loss of worms thus permitted to hatch too early, they may be fed on lettuce, upon which it is well ascertained that they can be well sustained in their early stage. The experiments of General Mordaunt, in England, were referred to long since.† Miss Rhodes fed them, upon two occasions, successfully, with this food. She gave it to the first parcel for the first week, and then substituted mulberry leaves. Upon a second occasion, the worms came out on the first of June, and were kept on lettuce until the 24th of the month. Mulberry leaves were then given; in less than a week after the change of food, they began to spin, and the cocoons were as fine and as firm as any she ever had. She did not lose a dozen worms of many thousands.‡ Her experience has recently been confirmed by

* By maceration is commonly understood eggs preserved in bags, under cushions or mattresses, or in blankets, and similar things, until the moment of putting them in the stove-house.

This uncertain method must be injurious to the regular and secure developement of the worms. It often happens that great quantities are spoiled by maceration, the worms coming forth, and shortly dying.

It appears rational that, when there is a certain and regular method, we should not adopt another, the result of which is uncertain and irregular, particularly when this secure method is not attended by any great expense.

† Bee, by Dr. Anderson. Edinburgh, vol. 8. p. 262.

‡ Trans. Soc. Arts, Lond. vol. 4, p. 149.

that of Miss Pether, who fed silkworms on cabbage lettuce, until the last change of their skins, when she substituted mulberry leaves until they began to spin their cocoons. The silk produced under this treatment was pronounced by a silk manufacturer, and three dealers in silk, to be equal to the average quality of the silk of the continent, and much superior to that of the East Indies. With an improved mode of reeling, it would have been equal to the better sorts of Italian silk.* Other food has also been employed with success. In the valuable paper on the silk culture, before referred to, in the second volume of the Transactions of the American Philosophical Society,† it is stated that, in Italy, rose leaves are used; but the late vegetation of that plant may prevent its general use. Mr. Loudon‡ mentions, that M. Bonafous, an experienced cultivator of silkworms, found that "dandelion sustained them until the fourth change, when the leaves of the mulberry were substituted." If this plant should answer in the United States, the fact is important, as it is the first vegetable that appears in the spring.§ Various works, during the last thirty years, have repeated the following statement, viz: that Dr. Bellardi, of Turin, after a number of experiments, found that young worms eat dried mulberry leaves with avidity. The leaves must be collected about the end of autumn, before frost, and in dry weather, and at a time when the heat is greatest; then dried in the sun, and laid up in a dry place, after they have been reduced to powder. When given to the worms, this powder should be slightly moistened with water, and a parcel of it placed before the worms. This practice, according to Du Halde,|| is pursued in China, with this difference, that the leaves are merely kept in earthen jars.¶

When the egg assumes a whitish color, the worm is already formed, and, with a glass, may be seen within the shell. The eggs should then be covered with white paper, well pierced with a particular instrument;** the paper so cut as to cover them all. The worms will appear upon this paper, climbing through the holes. A clear muslin will do as well as paper. To collect the worms, small twigs of mulberry, with only two or three leaves on them, should be laid on the paper, and they should be increased as fast as the worms come out upon them;

* Trans. Soc. Arts, Lond. vol. 44, p. 71. Miss P. received a premium from the Society for her silk. Mr. Swayne says that his worms, the eggs of which came from Turin, obstinately refused to touch lettuce leaves. Trans. Soc. Arts, vol. 10, p. 187.

† p. 352.

‡ Gardener's Mag. vol. 2, p. 346. Lond. July, 1827.

§ Both lettuce and dandelion were long since mentioned, as food upon which young worms could be sustained. Essay upon the Silkworm, by Henry Barham. London, 1719, preface.

|| History of China, vol. 2, p. 367. London, 1741.

¶ The writer wishes it to be distinctly understood, that the above substitutes for the proper food of silkworms ought only to be used when this cannot be had. Due attention, except in a very late spring, will always enable us to accommodate the hatching of the worms to the vegetation of the mulberry tree.

** A pricker, similar to that of a biscuit baker's docker, will answer perfectly. The use of the pierced paper must never be omitted.

for, if they do not find the leaves, they get out of the boxes. Few worms appear the first day; and if the number of them is very inconsiderable, they should be thrown away, because, when mixed with the later worms, they would grow faster, and become mature so much sooner that they would only be troublesome.

The worms which may have been managed according to the method just stated, will always be healthy and strong. They will never be red nor black, but of a dark hazel color, or chestnut, which is the proper color they should have. When the worms are red at their first coming out, it is a sign the eggs have either been bad, or ill kept over winter, or overheated: that is, too much forced, when laid to hatch. Worms of this color are good for nothing, and should be thrown away, since they will not produce cocoons.*

To prevent the young leaves from drying, which they will do rapidly, they must be put loose in clean stone jars, if convenient, covered, and placed in a vault or cellar. A stock of leaves, at least for three days, should always be in the house, to secure food in the event of wet weather.

The essential point is to cause the eggs to be hatched with the greatest ease. If the success of this operation be not complete, the worms will probably be subject to disease through their whole course of life, as will be shown.

The appearance of the new hatched worms is that of a woolly substance, of a dark chestnut hue, in which is perceptible a general stirring of minute animals, rearing up, and presenting a black and shining speck or head. While the eggs are in the stove-room, they should be stirred around with the spoon two or three times a day. This operation hastens their coming forth. When the temperature of the stove-room is raised to 75°, it is advantageous to have two dishes, in which water may be poured, so as to offer a surface of nearly four inches diameter. In four days there will have taken place an evaporation of nearly twelve ounces of water; the moisture, which rises very slowly, moderates the dryness which might occur in the stove-room. Very dry air is not favorable to the developement of silkworms.†

A prudent cultivator has done all in his power, when, on observing the season favorable, and the bud of the mulberry shoots in a proper degree of forwardness, he has put the eggs into the stove-room. Should the weather suddenly change, as it did in Italy in the year 1814, it is then of great use to have the power of backening the hatching of the eggs, without injuring the worms, and to prolong their two first stages by a few days. To obtain this, the only method is, after the worms have been removed into the laboratory about five hours, to lower the temperature to 73° from 75°; four hours after, further to lower it to 71°, and the following day to 68°, if necessary.

* Stephenson: Trans. Soc. Arts. London, vol. 43.

† In this place it may be proper to caution the cultivator against exposing the worms to the smell of tobacco, which is a cause of certain death to them. A number was recently put in a box which had contained segars, and many of them died, although the box was lined with clean paper. No smoking should be permitted in the room in which silkworms are.

This cooling of the air diminishes the hunger of the young silkworm by degrees, and without danger; and, by these means, the modifications are prevented, which, at 75°, would have brought on the casting or moulting much more speedily. At 75°, the first moulting is effected the fifth day; whilst at 71° it requires six or seven days. The second moulting, which, at 75°, is wrought in four days, at 69° and 71° takes six days for its accomplishment. Thus, by foresight and prudence, the proprietor will be enabled to gain seven or eight days, which prevents any ill effect from the unfavorableness of the season; and this time gained, it is evident, may be of the utmost consequence. In 1813, the silkworms were reared in thirty-one days, and it required thirty-eight days to raise them in 1814, to allow time for the growth of the mulberry leaf: and there are not comprised, in these seven days gained, the three days of delay in the hatching of the silkworms, having perceived that the whole season was bad. Those who are not careful thus to meet the accidental untowardness of seasons, and by art to prevent their injuries, would be obliged either to throw away the early hatched eggs, or to strip the mulberry tree too soon, and injure the leaves which are to feed the silkworm in its adult stages hereafter. These considerations must strongly impress the necessity of delaying the hatching of the eggs by some days, rather than hurry their coming forth, particularly as there is no fear, when worms are reared in this secure manner, of their being injured. Should there occur two or three hot days, these would only accelerate the moulting a few days sooner. It is also certain, that the later silkworms, in their last stage of progress, make choice of the leaves suitable to their age, and particularly those leaves which are quite ripened, which, for the proprietor's interest, is the most important period, as it is at that last period the greatest consumption of the leaves occurs.

It is easy to imagine that it may often require more than three days, even to bring forth the silkworms, from a given quantity of eggs. It will be seen hereafter, that the moths do not issue from the cocoons in less than ten days or a fortnight, according to the temperature to which they have been exposed; and it is therefore evident, there may be a difference of ten days or a fortnight in the laying the eggs. As the eggs put to hatch are not, therefore, all laid the same day, and are liable to the same degree of heat in the stove-room, some must come out sooner than others:* hence, no one can say the late hatched eggs can be either better or worse than the early eggs, because the embryo has required longer to perfect itself into the worm: this period is always pro-

* It does not appear correct to say that, because the eggs are not all laid in one day, they cannot be hatched in one day. If we may argue by analogy, it is well known that hens hatch eggs laid at various periods in a short time. Housewives well know, when they choose eggs for setting, that, provided they be good eggs, their having been laid at different times is of no consequence. It would appear that it is not because the eggs of the silkworms have been laid sooner or later, that they do not hatch at one time; but, more probably, this difference proceeds from the peculiar quality of the egg, and of the care taken to surround it constantly with the degree of heat it may individually require.

portioned to the constitution of the eggs. These reflections should satisfy those who have one box of eggs, and one single room to rear the worms in, how much it imports that he should not reckon on the very late hatched eggs, that he may not have worms of a day old mixed with worms four days old, thus interfering with the general progress of cultivation. The proprietor, on the contrary, who has many boxes of eggs to bring forth, can dispose of the early or late eggs to other persons; and, by these means, need never mix the silkworms of different ages. Then, if one person holds those of the first day's hatching, and another holds the worms hatched the fourth day, no evil accrues; all proceeds with regularity and ease, as each person has equal-aged silkworms to attend to.

When the proprietor has only a small box of eggs to hatch, it is better to cast away those that come forth the first day, and not to reckon on those that are not come forth the third day; and thus, by having only those hatched in the two intermediate days to attend to, much trouble will be saved. It is far better to lose a few worms of the first day's hatching, and eggs not hatched the third day, than to suffer the inconvenience, during the whole progress of rearing them: by adding a small quantity of eggs to those that are next to be hatched, the loss is easily made up. These directions are recommended to be exactly followed up; they will guide, simplify, and ameliorate the cultivation of silkworms. If they are not attended to, the exact proportion of eggs which produces the worms will not be known, and there will be constantly on the tables worms of different sizes, with differing necessities, and failure and trouble will ensue.

It is thought proper, in this place, to give the practice of a gentleman of Montauban, in France, who, according to Mr. Stephenson, had uncommon success in rearing silkworms.

Having long observed that the worms which were first hatched, turned out always to be more healthy and vigorous than those which were later in coming out, he made it a point to save no more than the production of the three first days, throwing away all the rest. He likewise made it a rule, upon their passing through their different moultings, to take only the forward worms, throwing away regularly all those which remain long in recovering from them: having, for many years, observed that those worms which are hatched after the third day, always turn out weakly, and are tedious in all their operations. For the same reason, he rejected all those worms which linger in getting over their moultings, which he ascribed to their weakness, or to their being infected, in some measure, with some disease, which generally carried them off before they could make their cocoons; or, if they did reach the length to make them, these were so light that they were not equal to the expense of the leaves. When worms were recovering from their moultings, he saved only such as came away the first two days, and threw away all that were not ready at the close of the second day.

It must be obvious, that this system is calculated to ensure a sound, vigorous, and annually improving breed.*

When the worms are laid upon the papers, they should be given some young leaves, covering the spaces between the twigs with them, that, by degrees, the whole surface may be equally spread with silkworms. In case they should get into heaps, a leaf might be put over them, to which they will adhere; and, being gently lifted, it may be put in any spot where the worms lie thinner.

Whenever silkworms are added upon the paper where some worms have already been deposited, they should have food given them; but the worms that were first on the paper should not be again fed until the other sheets of paper have been filled. Thus a fair number of the first worms will receive the second meal at one time.

The worms take at least two days to come forth; consequently, the first hatched will be larger than those that appear the second and third days. We have stated above, that the thermometer proves, that a room can never be heated to a degree exactly equal in every point of space. There will exist the difference of a degree, and even more. By putting the early worms in the coolest part of the room, and the late hatched worms in the hottest, and by feeding the latter rather higher, it is practicable to bring them nearly to an equality.

It has been said, that, if the worms which appear the first day are in very small quantity, as it mostly happens, it is of no consequence, because the main portion comes forth the second and third days. However, if it is required that those first hatched should be reared, they ought to be put in an angle of the sheet of paper belonging to the number of their box, and only be allowed half the quantity of food which is given to those later worms, on the first and second day.

In general, the silkworms come forth more abundantly in the forenoon, when the sun shines warmly into the room; the room being then hotter than at night. The great alterations to which the eggs are exposed, occur in the night: if those who have the care of the silkworms at night, heap up the fire, that they may take their rest without having to make it up, the augmentation of heat affects, and even spoils the embryo.

It has been observed, that, some days, the hatching of the worms was most abundant in some boxes, and equally so in all the hours of the day as in the morning.

Where worms are fed on shares, an easy and beneficial improvement would be, that all the eggs be hatched in boxes capable of holding twenty or thirty ounces, constructed in the proportions before-mentioned, and that as fast as the worms come forth, the sheets of paper should be

* Notwithstanding Dandolo is our chief pilot in the rearing of silkworms, it is deemed important to direct the attention of the reader to the different practice of the experienced cultivator referred to above. If the direction of Dandolo, to throw away the worms of the first and fourth days' hatching, be not adopted, we should never omit to keep the productions of those days separate from the others hatched on the two first days, in order that each parcel may be brought forward as equal as possible, and that all the worms contained in it, may be in readiness to form cocoons on the same day, or within two days of one another.

arranged to receive the ounce of silkworms in regular order, as has also been before explained. By this method, each person would receive worms hatched nearly the same hour, perfectly equal. When all the silkworms are hatched, they should be divided into ounces, as nearly as possible, and put upon the sheets of paper. The earliest should be given to those cultivators whose mulberry trees are most advanced. Should the hatching continue three days upon this plan, it would make no difficulty, as different persons would take the worms of various ages, and thus each would have the silkworms of one period. It is a great error to imagine that it can be advantageous to give a person silkworms of various days hatching, to make up the quantity he is to receive and rear; because those of the first day's production are stronger than those of the second day, or of the third and fourth days. We repeat it, the essential point is to have the worms as nearly equal as we can bring them.

CHAPTER VII.

OF THE SMALL APARTMENT TO WHICH THE NEW HATCHED WORMS SHOULD BE REMOVED, AND OF THEIR REMOVAL.

We shall, in this chapter, treat of the following subjects:

I. Of the apartment destined to receive the new hatched silkworms.
II. Of moving the silkworms directly after they are hatched.

I. *Of the Laboratory destined to receive the silkworms newly hatched.*

This small habitation is to contain the silkworm until its third casting of skin, or moulting.* The room should be in exact proportion to the number of silkworms, and calculated for facilitating the attendance upon them. Thus proportioned, it will be economical, as there will not be that quantity of fuel used, which it would take to warm either one very large room or several small ones.

The worms proceeding from an ounce of eggs, require, until the first moulting of the skin, a space of about seven feet ten inches square.

Until the second moulting, a space of about fifteen feet four inches square.

Until the third moulting, a space of thirty-five feet square.

* In explaining the use of the small laboratory, it will be shown how much more economical it is, than apartments either too large or too small. However, others must be guided by their own convenience, in making use of those rooms they find suitable. And, should there be but one apartment for the rearing of the silkworms until the cocoon be formed, it would be of small consequence, provided attention were given to maintain, with exactness, the temperature, in all its degrees, which will be indicated. One room suffices, particularly for those who hatch but a small quantity of silkworms, if they have wicker tables enough to admit of sufficient space between the worms. These should be two hundred and ten feet square, for disposing of the silkworms proceeding from one ounce weight.

The hurdles or wicker trays should be placed above one another, at a distance of twenty-two inches at least; and as many should be put, as are required to give the space necessary for the quantity of silkworms which are to be accommodated.

The worms must be kept upon paper, which should line the wicker trays, and extend a little beyond, to prevent the worms falling off.* Upon this paper, which should be strong, ought to be inscribed the corresponding numbers to those on the boxes; thus avoiding every chance of the silkworms of different boxes being mixed.

According to the size of the room, there should be one or more thermometers, one or two small fire-places in the angles, one or two ventilators in the ceiling, or in the floor, and one or more windows; and also as many doors as may be convenient. In this room it might be proper to place a stove, similar to that in the stove-room, as in cold weather it may be used to save fuel.

The principal advantage of the small fire-places, is, not so much the warming the air, as the making a draught or current through it, as we shall show hereafter. The temperature of this laboratory should be carried to 75°: about two degrees lower than the stove room heat which hatched the eggs. Experience teaches us that, as the silkworm grows older, and gets stronger, it requires less heat.

Such is the temperature that suits these insects shortly after they are hatched. Should the season be peculiarly unfavorable, and the vegetation of the mulberry tree checked, it might be necessary to slacken the temperature, and thus gain a few days by gradually lowering the heat to seventy-one degrees, and even to sixty-eight degrees; but not beyond that.

II. *Of the removal of the new-hatched silkworm into the laboratory, or elsewhere.*

The silkworm should be removed, as soon as possible, into the apartment in which they are to remain until their third moulting, unless it is intended they should be reared in the stove-room. If a different room is proposed for the rearing of these insects, until their third moulting, it is because it is found both more convenient and more advantageous.

When they are about to be removed from the stove-room, three circumstances must be noticed, relative to the manner of transporting them.

In the first place, whether the silkworms are to be reared in the same house in which they have been hatched.

Secondly, if part of them are to be reared in the house, and the rest removed.

And lastly, if all are to be removed.

1. Let us suppose all the worms are to be reared in the same place.

* The edges should also be turned up about an inch and a half.

When the little twigs spread over the perforated paper which covered the eggs of the silkworms in the small boxes, are loaded with the young worms, these boxes are all put upon trays made to carry them, and they are removed to the laboratory.

When all the sheets of coarse paper, accurately numbered, have been laid on the wicker hurdles, the small box of the corresponding number, is put on the edge of the wicker hurdle, and with a small hook, the twigs, covered with the worms, are gently lifted off the perforated paper on the box, and put upon the paper laid on the wicker hurdles. A hook should be used, as the touch of the hands might injure the insects.* In laying the twigs on the paper, care must be had to allow space enough for mulberry leaves to be put over the twigs and between them, that the insects may have room to stretch and properly distribute themselves. It should be noted here, that the silkworms produced from one ounce of eggs thus disposed, should occupy a space of twenty square inches. Each sheet of coarse paper, on the hurdle, will cover a space of nearly twenty-two square inches: being twenty-three inches long, and twenty-one inches wide. Having a care to lay the worms in squares of ten inches, four sheets of paper will be the number required to hold the produce of one ounce of eggs, which will exactly allow the worms the space they need, until after their first moulting. The sheets of paper will be four times the size of the small boxes, and those four sheets of paper must bear the same number as the box; and thus the worms will not want moving till their first moulting has passed.

As fast as the silkworms come forth, they should be moved in this manner.

2. We are to suppose that a portion of the silkworms is to be reared in the house in which they have been hatched, and the rest to be reared elsewhere.

When the cultivator shall have taken home with him his proportion of the silkworms upon these sheets of paper containing one ounce, he must put the square of silkworms into four small squares of ten inches each, thus forming four quarters of one sheet, or rather four small sheets. This division is easily effected, by passing the hands under the litter of leaves to which the worms cling, and parting the leaves gently, when it is required to divide the mass; it separates easily, and may be subdivided at pleasure. The parts should be as even as possible. If, in the first ages, all the care described is not taken, numbers will be lost; they will be unequal, and contract numberless diseases.

3. We are to suppose all the silkworms are to be removed from the house in which they were hatched.

In a box calculated for removing easily, and proportioned to the size of the sheets of paper, should be put several of these sheets, covered with silkworms in layers above each other, at the distance of

* The hook should be blunt, to prevent injury to the worms See plate 1, fig. 7,

nearly two inches; or common baskets may be used. The removal in baskets may be executed in safety, with the following precautions:

1. Lining the baskets thoroughly with paper well closed, that the exterior air may not strike the silkworms, particularly if it should be cold.

2. Preventing the sheets of paper covered with worms, from touching each other, by putting slender sticks across to support the sheets of paper, and avoiding their pressing together. This should be done in as many layers, from the bottom of the basket to the top, as there are sheets of paper covered with the young worms, leaving a distance of four fingers between each.

3. To cover the basket very completely with linen cloths, to keep off cold and sun.

4. To remove them between the hours of twelve and three o'clock, that being the hottest part of the day.

5 To give the worms a small quantity of young and chopped leaves if their journey is likely to be three or four hours long.

The proportion of the boxes stated as necessary for hatching the silkworms, should not be altered; as this proportion prevents any necessity of ever touching the eggs, from the moment the silkworms begin to appear.

The perforated paper being large enough to support a number of small twigs of mulberry, it consequently enables us to remove a large portion of the silkworms at once. In using these small boxes, the egg shells will always adhere together, and when the boxes are lifted, they should be slightly shaken horizontally, to move the eggs. If, in moving them, some of the holes in the paper should be stopped up with the eggs, it is of no consequence, as it will not prevent the worms climbing up.

Whenever a sheet of paper is prepared for the arrangement of silkworms, there should be inscribed upon the paper itself, the hour in which the arrangement began; thus it will be seen in what time, and in what progression, the silkworms come forth. A pencil may be used, for the purpose of noting the sheets of paper.

CHAPTER VIII.

OF THE REARING OF SILKWORMS IN THEIR FOUR FIRST STAGES.

In the preceding chapter it has been stated, that the space suitable to the number of silkworms proceeding from one ounce of eggs, should be, in the first age, that is to say, until the first moulting, 7 feet 4 inches square. Of about 14 feet 8 inches, until the second moulting; and of 34 feet 10 inches, until the third moulting. The space required until the fourth moulting, is 82 feet six inches square.

Those who have the means of extending these allotted spaces, may do so by some feet; because it is certain, that the more room silkworms are allowed, the better they eat, digest, breathe, perspire, and rest. The spaces mentioned are sufficient, and present the advantage of facilitating the attendance on the silkworms, and economizing their food.

It may not be without advantage, exactly to know, what quantity of the mulberry leaf the silkworm consumes in its four first ages.

For the quantity of food fixed, the following circumstances must be supposed to exist:

That the silkworms are kept until the first casting or moulting, at 75° of temperature; between 73° and 75° until the second moulting; between 71° and 73° until the third; and, lastly, between 68° and 71° till the fourth moulting.

One of the foundations of the art of rearing the silkworm, is to know and determine the various degrees of heat in which, according to their ages, the silkworms are to live. If this precept is not rigidly enforced, nothing can be performed with exactness.

The writer of an article upon silkworms, inserted in Rosier's "*Cour d'Agriculture*," Paris, 1801, article *Vers a Soie*, thus expresses himself on this subject: "A sudden change from moderate heat to violent heat, or, in general, from heat to cold, and cold to heat, is highly injurious to silkworms. In their native climate they are not exposed to these vicissitudes, and therefore thrive well, without requiring all the care we are obliged to bestow on them. With us, on the contrary, the temperature of the atmosphere is so variable, that, without artificial means, we could not fix it in our laboratories for rearing silkworms. If it should happen to be necessary to hasten the worms, in consequence of the advanced state of the mulberry leaves, it should be done gradually, so that they do not perceive the alteration."

All the practical writers, expressly consulted on this subject, are agreed. It is, moreover, conformable to the well known principle of animal life, (which is always more or less affected by sudden changes of temperature,) to hatch the worms by the gradual exposure of them to heat. The American cultivator must always, therefore, bear it in mind, if he expects to be fully paid for the trouble, time, and expense bestowed on silkworms.

The English translator of Dandolo, has indeed inserted a note in this place, containing a passage from the Abbe Sauvage, by which it would seem that young silkworms will bear, with impunity, a much greater heat than the highest degree to which Dandolo limits them, in their early age. Sauvage says, that "he gave them 100° of heat during the two first days after hatching, and about 95° during the remainder of the first and second age, and yet had a most abundant crop." But the translator has omitted to say that Sauvage does not recommend the practice. On the contrary, this author expressly says, that "he leaves to his readers to follow as they please the two modes of rearing the worms pointed out by him;" one with a more gentle heat, and the other with an increased degree; and, in two places, (pages 22, 35,

2d memoir,) advises a mean between them. The experiment of Sauvage was a single one. Dandolo writes after years of practice, upon a very large scale, and recommends the degrees of heat which always ensured him success. Other practical writers agree with Dandolo. No one, it is presumed, will be at a loss to decide which of these authorities is most worthy of being followed.

The silkworms proceeding from one ounce of eggs, consume—

1st. In the first age, (that is to say, when all are hatched, removed, and distributed upon the sheets of paper, which includes at least two days,) six pounds of leaves well sorted, and chopped very small.

2d. In the second age, they consume 13 pounds of leaves, chopped rather more coarsely than the food in the first age.

3d. In the 3d age, they consume 60 pounds, still less chopped.

4th. In the fourth age, 180 pounds, still less chopped than in the third age.

Some circumstances may modify the proportions above specified, but these variations are not important, supposing the cultivator to act with considerate intelligence, and to time well the hatching of his silkworms with the springing of the young leaves, and then their growth with the progress of the leaf through the other stages of existence.

The only case in which the quantity of leaves fixed, in these general rules, for the consumption of the worms, will be found unnecessarily excessive, will be, if the worms have been ill attended and fall sick, pine away, and that many die. The quantity of leaves necessary for silkworms was determined, after having made the most exact experiments repeatedly; taking for granted, that the silkworms are maintained in the degrees of temperature indicated, and with the view, as much as possible, to economize the leaves; because, when an exact sufficiency of food is given to the worm, it eats with greater relish, digests well, and is strong. A great object in the art of rearing silkworms, is, to contrive to obtain the greatest possible quantity of fine cocoons, with the least quantity of leaves.

In managing upon this principle, the more leaves there are, the greater will be the proportion of cocoons, and consequently the greater the profit. Over-feeding, however, must always be guarded against: it not only causes a waste of leaves, but is the origin of many inconveniences which assail the silkworm, as we shall show hereafter. The cares which the silkworm requires in its four first ages, are neither numerous nor puzzling; although it is in those ages, and particularly in the two first, that the strength of its constitution is formed, upon which the ultimate success depends.

The two first days after it has cast the skin, it eats sparingly, and then becomes voracious: this hunger soon diminishes, and even ceases. These phenomena occur in every moulting. Thus, notwithstanding the strength of its constitution, if it is not treated with the greatest care, at those times when it requires care, it suffers, sickens, and dies: on this account, it is thought it might be useful to give in this and the following chapter, a diary of the care to be taken of silkworms, that it

may be known what is to be done for them day by day. A few gener al remarks, however, must be previously made, on the great difference in result, which real care produces.*

The laboratories used, are of various sizes: that which will now be referred to, is calculated for the reception of the worms proceeding from five ounces of eggs.

It must be allowed that the advantage of the mode of rearing silk-worms in question, might perhaps be trifling, if it were only in the product of the hundred and ten, or hundred and twenty pounds of cocoons from each ounce of eggs, which others obtain, consuming the same quantity of leaves, and differing only in the hatching of two ounces of eggs. But, as before remarked, the great and principal aim of the art of rearing silkworms, is to obtain from one given quantity of mulberry leaves, the greatest possible number of cocoons of the finest quality. It is not the trifling loss of an ounce of eggs which should induce a change of system of habits, but the following advantages: for it is a fact, that,

1st. When, with one ounce of eggs one hundred and ten or one hundred and twenty pounds of cocoons are obtained, about one thousand six hundred and fifty pounds of the mulberry leaf will be used.

2d. That when only fifty-five or sixty pounds of cocoons are produced from one ounce of eggs, about one thousand and fifty pounds of mulberry leaves have been used. Under this supposition, it would appear that two thousand one hundred pounds of leaves are requisite to produce one hundred and ten, or one hundred and twenty pounds of cocoons.

3d. That one hundred and ten, or one hundred and twenty pounds of cocoons, obtained from one ounce of eggs, are worth a great deal more than a similar quantity obtained from two ounces of eggs. It is easy to prove these facts.

If one ounce of eggs shall have produced, by the means stated, one hundred and twenty pounds of cocoons, they will be fine; three hundred and sixty, at most, will produce a pound and a-half; and eleven or twelve ounces, at most, of these cocoons, will yield an ounce of exquisitely fine silk. When only fifty or sixty pounds of cocoons come from one ounce of eggs, it may generally be presumed that they are of inferior quality to the above, and it will require four hundred at least to make one pound and a half; and above thirteen ounces of these cocoons, instead of eleven or twelve ounces, to form one ounce of silk. Moreover, when the worms have not been properly managed, there is no certainty as to the quantity of the cocoons that will be gathered; and it happens, continually, that the same cultivator will, from the same

* The greatest enemy of the silkworm is the red ant, the attacks of which insects must be carefully guarded against. To this end, all nail holes in the walls of the apartment should be filled with mortar; the sides of the breeding frames ought not to touch the walls, nor ought their posts to reach to the ceiling. Streaks of thick molasses must also be made round the lower parts of the posts. If the worms be fed on tables, or moveable frames, similar to those of the Rev. Mr. Swayne, the same precautions may be used, or the legs may stand in a plate or bowl of water.

Cockroaches and mice must also be carefully guarded against.

quantity of eggs, and the quality of the leaves, obtain at one time a number of cocoons, at another time few, and sometimes none.

This chapter shall be divided into four paragraphs:

1. Rearing of the hatched worms until the end of the first age.
2. Rearing of the worms in the second age.
3. Rearing of the worms in the third age.
4. Rearing of the worms in the fourth age.

1. REARING OF THE WORMS IN THE FIRST AGE.

We left in the small laboratory the worms hatched from the eggs at 75° temperature, and distributed upon sheets of paper, in squares of about ten inches. Let us now begin their training. Supposing it is required to rear five ounces, which form a good sized laboratory, the space and quantity of leaves must be proportioned to the stated number of silkworms.

First day's training.—When the worms have accomplished their first casting of skin, they should occupy a space of nearly thirty-six feet eight inches square; hence the sheets of paper containing the worms, should be put upon wicker tables or trays, of these dimensions.

The first day after the coming forth, and the distribution of the silkworms, they should be given in four meals, about three pounds three quarters of single soft leaves, chopped very small, dividing the time, so as to allow six hours between each meal; giving the smallest quantity for the first feeding, and gradually increasing the quantity at each meal.

It is very beneficial to chop the leaf very small during the first age, and to scatter it lightly over the worms. The more the leaf is chopped, the more fresh cut edges are there to which the young insects fasten themselves. In this manner, a few ounces of leaves will present so many edges and sides, that two hundred thousand insects may feed in a very small space. In this state, they bite the leaf quickly, and it is consumed before can it be withered.*

A quantity of leaves, ten or twenty times more abundant, that is not chopped small, would not be sufficient for this quantity of worms; because they require to find at once, and in a small space, the means of feeding easily.

* It would seem to be unnecessary to chop the very young leaves, so repeatedly insisted on by Dandolo. When a whole young leaf is placed on worms recently hatched, they eat through the middle of it, and ascend to the upper surface, on which they continue to feed, until the whole leaf is consumed. After some days, they prefer to eat the edges of the leaves: injury might even ensue from the quantity of moisture, which the young insects would imbibe from the bruised edges of the young and chopped leaves: cultivators must make comparative experiments to determine the point. When the leaves have attained some size, then the chopping of them is indispensably requisite. For a small quantity, the semicircular double chopping knife recommended by Dandolo, and figured in plate 2d, fig. 3d, answers well. Upon a large scale, a straw cutting box may be used. In both cases, the knives should be kept very sharp, to prevent the bruising of the leaves. It is important to remark, that the leaves must not be cut until the moment they are wanted; nor must any leaves be given which are covered with a substance like manna.

The worms must be fed regularly four times a day, and so managed as never to give the whole quantity at once, as stated above; because, after the distribution of each meal, it is better to observe if some food should not be added in different spots. It is sometimes good to give them a little food at intermediate times, as will be seen hereafter.

The quantity of food fixed, which will be again specified, is that necessary for the whole day. In about an hour and a half, the silkworm devours its portion of the leaves, and then remains more or less quiet.

Whenever the food is given, care should be taken to spread and widen the small squares by degrees. If any of the chopped leaf should be scattered, it may be swept with a small broom into its place again.

Second day.—On this day, about six pounds will be needed, chopped very small. This will suffice for the four regular meals, the first of which should be the least, increasing them as they proceed, as was done in the meals of the first day.

The worm now begins to change in appearance; it no longer looks so dingy, or so bristled; the head enlarges, and whitens considerably.

Third day.—This day twelve pounds of soft leaves, chopped very small, will be required for the four meals; the worms will now feed with avidity, and nearly the two-thirds of the sheets of paper should be engrossed by them.

To satisfy the increased hunger of the insects, they should be given a pound and a half of leaves slightly scattered over them; should they devour it quickly, in an hour they should have an intermediate feeding, about half the quantity of the first meal, scattering the leaf very sparingly. This day the head of the silkworm is much whiter, the insects have perceptibly grown larger, and scarcely any hairiness can be perceived on them with the naked eye. The skin is of a sort of hazel color. When seen through a magnifying glass, their surfaces look shining, and their heads are of a silvery bright appearance, like mother-of-pearl, and rather transparent.

Fourth day.—This day six pounds twelve ounces of chopped leaves should be given, for the quantity should be diminished as the appetite decreases; the first meal should be of about two pounds four ounces, and the other meals should decrease in proportion as the quantity of leaves given before appears not to have been thoroughly eaten.

The cultivator must regulate the intermediate meals upon the apparent appetite of the silkworms, taking the food for them from the quantity of leaves allotted for the whole consumption of the day. The space on the sheets of paper, must visibly get covered with the worms. It is important, in this first age, to give the worms a plenty of room, by gently separating and spreading them, to avoid, as much as possible, their sleeping in heaps together. The constant care of enlarging the squares by degrees, when the worms are fed, will gradually lead them to stretch out as they grow, and prevent their getting into heaps, which is very injurious to their constitution, health, and to that equality of size which it is so desirable to maintain among them.

At the beginning of this day, many of the silkworms begin shaking their heads, which indicates that they feel overloaded by their skins. Some of them eat little, but keep their heads reared up: with a magnifying glass it may be seen that their heads are increased much, and grown very shining. The whole body of the insect seems transparent, and those that are near their time of moulting, when seen against the light, are of a yellow livid tinge: towards the close of this day, the greatest number of the silkworms appear torpid, and eat no more. As a general rule, it is proper here to apprize the cultivator, that, during the time of moulting, the worms must not be disturbed, for the process of changing their skins will thereby be interrupted. "The hurdles should be cleaned before and after every moulting, until the fourth age, once during that age, before and after the fourth or last moulting, and every two days during the fifth age.*

Fifth day.—This day one pound and a half of young leaves, chopped small, will be about sufficient. They should be scattered very lightly several times in the day on the sheets of paper, where there appears still to be worms feeding. Should the worms have ceased [illegible] feeding, it would be unnecessary to distribute any further quantity. What has been said as to the different variations of quantity required by the silkworms of this age, is applicable to all the other ages. Economy and regularity in the distribution of the leaves cannot be too much urged.

Towards the end of this day the worms are torpid; a few begin to revive.

After the first moulting, the silkworm is of a dark ash color, showing a very distinct vermicular motion. The rings that compose its body, stretch and shrink more freely than heretofore.

It must here be repeated, that it is of the utmost import that the food should now be chopped very finely, first with a knife, and then with a double-bladed hashing tool.

When the weather admits of it, the leaves should be gathered several hours before the meal is given; they last very well a day, and more, if kept in a damp cool place, where there is no draught of air. It is always desirable the leaf should have lost its first sharpness, and not be given to the worms till six or eight hours after it has been gathered.

A general view of this paragraph will now be exhibited, and a few observations added that appear to be useful.

The first age of the silkworm, reared in the temperature indicated, is almost always accomplished in five days, exclusive of the two days employed in their coming forth, and being removed and distributed. In this first stage, the silkworms proceeding from five ounces of eggs, have consumed thirty pounds of picked leaves, chopped small; in adding four pounds and a half, the refuse picked off the leaves, the weight will make thirty-four and a half pounds of mulberry leaves, or about seven pounds of leaves from the tree to each ounce of silkworms.

* Nysten, p. 105. Recherches sur les Maladies des Vers a Soie, p. 105—Paris, 1808.

To complete the exactness of these observations, we must add two other alterations, to which the silkworms are subject before their moulting.

1. We have seen that to form an ounce of silkworms just hatched, it requires 54,626 worms. After the first moulting, 3,840 are sufficient to make up that weight. Thus the silkworm has increased, in about six days, fourteen times its own weight.

2. Before the above six days, the silkworm was about a line* in length, and after those days it is about four lines long.

In the first age, the air of the laboratory should only be renewed by opening the doors. The necessary degree of temperature must be maintained by the stove and wood fires in the fire-places; as we shall show hereafter. Nothing further is necessary for the thriving of the worms, and their healthy continuance.

2. SECOND AGE.

Nearly seventy-three feet four inches square of the table or wicker trays, are needed for the accommodation of the worms proceeding from five ounces of eggs, until the accomplishment of their second casting, or moulting. The temperature to keep the worms in during their second age, should be 73° and 75°, as before said. The insects should not be lifted from their litter until they are nearly all revived. The manner of removing them will be shortly explained. There is no harm in waiting till they are all well awake and stirring, even should it be for twenty or thirty hours from the time when the few first began to revive.

When a great number of worms issue from the sheets of paper where they were placed, it is a sign that they should be removed from their litter, and by removing them a little sooner the others will soon revive also.

We have said already that during the first age most cultivators destroy the lives and the health of a vast number of worms, by not attending to them sufficiently. This inequality, and the evils resulting from it, are caused, 1st. By not having placed the silkworms in a space proportioned to their growth, in the course of their first age, which has allowed of some having fed well, while others could not feed; of some remaining under the litter, others upon it, which latter had the benefit of free air, instead of a close mephitical atmosphere; some began to fall into their torpid slumber sooner than others, and, being under the leaves, have moulted the last; others, in short, became torpid latest, and revived first, because they were upon the surface of the leaves, unloaded and unoppressed.

2d. By not having placed the sheets of silkworms hatched the first day, in the coolest parts of the laboratory.

3d. By not having placed the latest hatched worms in the hottest part of the laboratory.

* A line is the twelfth part of an inch.

4th, and finally, by not having given the last hatched silkworms intermediate meals, to bring on their growth a little faster. It follows from this want of attention, that when the silkworms should pass from their first casting or moulting, to the second, some worms are torpid, some are reviving and beginning to feed, and some have not yet fallen into the torpor which is to precede their change; and thus, on one wicker hurdle may we see silkworms of all sizes, which is very troublesome, to say no more; there is, besides, a great chance of the smaller worms perishing in their progress. All these losses will be avoided by strictly following the rules given.

First day of the second age.

(Sixth of the rearing of the silkworm.)

For this day will be needed nine pounds of young tender shoots, and nine pounds of mulberry leaves, well picked and chopped small.

The space of seventy-three feet four inches square, of hurdles, required for the second age of the silkworms proceeding from five ounces of eggs, should be duly prepared; and when nearly all the worms are roused, and begin moving their heads, and rearing up as if they sought something, those at the edge of the paper having already left the litter on which they had lain, preparations should be made to remove them, that the sheets of paper may be cleansed. The worms should be removed from those sheets of paper first, where they are perceived to be most revived and stirring. Small twigs of the young shoots of the mulberry tree, with six or eight leaves on them, should be put over the silkworms; these boughs should be placed so that when spread out there may be an inch or two between them. When one of the sheets of paper is thus covered with silkworms, another is begun, and so on, till all are completed. This must be done speedily. There should be some boughs left, which will be wanted. These boughs will gradually be entirely and thickly covered with worms. The small portable trays should be ready, upon which the boughs covered with worms must be put quickly, when taken off the sheets of paper.

Instead of forming small squares, as was done for disposing of the new hatched worms, long strips should be laid down the middle of the wicker hurdles, prepared so that by widening them on each side, when arrived at the consummation of the second age, the whole space of seventy-three feet four inches of the hurdle should be entirely covered by the silkworms.

The portable trays carry and place with ease the small boughs loaded with silkworms, and, by inclining them obliquely upon the hurdle, slip off the boughs gently into the strips allotted for them: being careful, lightly with the hands, to move those that may not be properly placed, filling the vacant spots with them, so as to render the distribution regular.

This operation concluded, some worms will be found to have remained upon the litter; with fresh boughs, these may be removed as-

the others were, and distributed upon the hurdles; should any after this remain torpid in the litter, they may be cast away. It is observable, that the silkworms like the tender boughs so much, that they are found heaped upon them, even when they have entirely eaten the leaves off, and never leave them to return to the litter below.

An hour or two after the worms have been placed upon the hurdles, they should be given a meal of three pounds of leaves chopped small.

When the boughs are stripped of the leaves by the worms, there will be bare spaces in the paper, and the boughs swarming with worms. To remedy this, the leaves should be gently laid on those bare places, and the worms stretching upon them, will equally spread and fill the strips. The space occupied by the worms should be widened a little when they are first fed. It should be remembered to sweep up, with a small broom, the leaves that may be scattered.

In the remainder of this day the silkworms should have, in two meals, the remaining six pounds of chopped leaves, with an interval of six hours between each, or according to the hours of the day which remain.

When the silkworms have been removed to the clean hurdles, those they have left should be thoroughly cleaned, the sheets of paper cleansed and rolled up, and taken out of the laboratory.

From the first day of the rearing of silkworms, until the first moulting, they consumed thirty pounds of leaves.

Second day of the second age.

(Seventh of the rearing of the silkworm.)

This day will be required about thirty pounds of chopped leaves; this quantity, divided into four portions, should be given at intervals of six hours, the two first meals less plentiful than the two remaining. It is very necessary gradually to widen on both sides the strips in which the worms are distributed, that, at the close of the day, two-thirds of the allotted space should be covered.

The body of the worm now acquires a clear hue, the head enlarges and becomes whiter. Should some places be thinly covered with worms, by placing small boughs where the worms lie thick, they will fasten on them, and may then be removed to fill up the places which were not sufficiently covered; the equality of the worms being very desirable, it should be constantly attended to, and those means practised which have been stated through all the moultings, and whenever circumstances require them.

Third day of the second age.

(Eighth of the rearing of the silkworm.)

This day thirty-three pounds of chopped leaves, well picked, will be necessary, and this time the two first meals should be the largest. The leaves should be distributed in proportion as they are wanted, and

with attention, because the voracity of the silkworm abates towards evening; and many worms show, by rearing their heads, and not eating, that they are approaching the period of torpor, and some already are become torpid. The strips should continue to be widened, so that at least four-fifths of the hurdle should be covered.

Fourth day of the second age.

(Ninth of the rearing of the silkworm.)

This day only nine pounds of picked leaves, chopped small, will be required. The silkworms sink into torpor, and the next day they will have cast their skins, and will be roused, and thus will the second age be accomplished. If, between the moultings, any worms should appear sick, and cease to eat, they must be removed to another room where the air is pure, and a little warmer than that they have left, put on clean paper, and some fresh leaves chopped fine given to them.

The alterations which the silk worm undergoes, besides that of the moulting in the second age, are as follows:

Their color becomes of a light gray; the hair is hardly to be perceived by the naked eye, and becomes shorter; the muzzle, which in the first age was very black, hard, and scaly, became immediately, upon moulting, white and soft, but afterwards again grew black, shining, and shelly, as before. As the insect grows older, at each moulting its muzzle hardens, because it needs to saw and bite larger and older leaves.

There appear now two curved lines, opposite each other, upon the silkworm's back.

The length of the silkworms, in the first age, was rather less than four lines; in the second age, of rather more than six lines.

In four days it has increased its average weight fourfold: when issuing from the first moulting, 3,240 silkworms formed one ounce: at this period, 610 will form this weight.

As the insect grows, it breathes more freely, its excrements are more plentiful, which, as the number of hurdles also increase in the laboratory, makes it necessary that the interior air should be more renovated; and to effect this, the ventilator in the floor, and the aperture made in the door, should be opened.

Should there be no wind, and the external air be cold, the ventilator may be left open until the thermometer has lost a degree, or, indeed, two complete degrees. Then all should be closed; the temperature again rises, and thus has the interior air been thoroughly renewed and purified.*

* Great care must be taken in picking and sorting the leaves for the worms of the first ages, such as picking off all the twigs and stalks of the leaves, and to clear them, as much as possible, from all useless parts. This operation is most essential in the two first ages. The sorting and picking is of importance, inasmuch as it enables us to put 15 or 20 per cent. less substance upon the trays, or frames, than would otherwise be done, and which the worms do not eat.

3. THIRD AGE.

First day of the third age.

(Tenth day of the rearing of the silkworm.)

In this first day, fifteen pounds of the small shoots will be necessary, and equally as much of the picked leaves, chopped rather less than hitherto; and, at the close of the age, may be still more coarsely chopped.

The temperature of the apartment, during this third age, should be from 71° to 73°. The worms that have accomplished the second age, should not be removed from the wicker hurdles, until they are all nearly roused. Part will rouse the ninth day; part the tenth. There would be no harm if those first revived should wait twenty-four hours, till the rest are all roused.

It is very easy to know the worms that are revived in this age: they issue from their old skin with so different an aspect, that any body may distinguish them without the aid of description. A never-failing sign that the silkworms are roused, is an undulating motion they make with their head, when horizontally blown upon. The impression of the air thus forcibly blown over them, is disagreeable and painful to them, when they have newly cast their skins; but gentle motion of the air through the laboratory is pleasant to them, and does them good, provided the renewed air is not colder than their usual atmosphere.

They should be removed in the same order and manner as in their former age.

The space of 174 feet allotted to the third age, should be disposed in a strip down the centre of the wicker hurdle, and of nearly half the width of the hurdle, so as to leave rather more than a quarter's width down each side of the strip. When the space is well ascertained which the silkworms are to occupy in their different ages, there is nothing more useful, and more economical, than to remove, cleanse, and place them in the manner described. Once placed upon their wicker hurdles, they are no more to be touched until their moulting is accomplished. They feed well, without interfering with one another, and without requiring to have the intervals on the sheets of paper cleaned. Their litter does not become mouldy, unless there should be a very unusual and continued dampness of weather.

The fifteen pounds of young shoots afford the silkworm its first meal, as in the preceding age. When they have eaten the leaves upon the shoots, they should have a second meal of about seven pounds and a half of the leaves—carefully filling with leaves the space between the shoots, to equalize the distribution of the worms upon the strips.

It must be unceasingly repeated, to ensure the silkworms continuing of an equal size, the cultivator must always watch those persons who distribute the food, that it may be perfectly even, and all the worms enabled to partake of it. A waste of leaves is not only a real loss,

but also is apt, by thickening the litter in heaps, to ferment, and thereby cause disease.

The worms should have their last meal this day, of seven pounds and a half of leaves, which completes the feeding of the day.

Should the removal of the litter be late in the day, so that the silk-worms could not be given the three meals, that portion of the leaves may be added to those of the following day. Two active, handy persons, should take but one hour to remove and distribute the worms upon 174 feet of hurdles.

As fast as the worms are lifted off, the litter should be carried out of the laboratory, rolled up in the sheets of paper. When taken out, the litter should be examined, in case any of the torpid worms may be remaining in it; and if this is done in any place sheltered from rain and wind, far from injuring the worms, it will tend to rouse them sooner than they would have roused in the laboratory, to which they must be taken back, by offering them young shoots, to which they will fasten, and thus be carried safely.

The latest worms should be placed apart, as their next moulting will be a day later also; or, should it be desired to bring them on equally with the others, by giving them rather more space between them on the hurdles, and putting them in the hottest part of the laboratory, this may be managed.

Now, as the worms begin to eat more, it is useful to employ a square basket, with which twice the work may be done in feeding the worms, compared to the usual method of holding the shoots and leaves in an apron, and feeding the worms with one hand only. By means of this basket, which may be suspended with a hook, and slide in a groove along the edge of the wicker trays, the feeder may arrange and distribute the food with both hands, and thus feed two trays of worms at once, by standing on high steps or ladders.

After two or three meals this day, there is a very sensible change in the silkworms. They are much larger, their muzzle is grown longer. and their color clearer.

Second day of the third age.

(Eleventh of the rearing of the silkworm.)

This day 90 pounds of picked leaves, chopped, will be needed.

The two first meals the least copious, because, towards the close of the day, the silkworms grow voraciously hungry.

The strips should be widened whenever they are fed, to allow them room.

Third day of the third age.

Twelfth of the rearing of the silkworm.

This day there should be given 97 pounds of picked leaves, chopped, divided into four meals—the two first meals the most plentiful.

Towards evening the hunger of the silkworm decreases; consequently, the last should be the least meal.

This day the silkworms grow fast, their skins whiten, the bodies are nearly transparent, and the heads are longer. If a hurdle of worms is seen against the light, before they are fed, they seem of the color of whitish amber, and appear powdery. The contortions they begin to make with their heads, show that their change approaches.

Fourth day of the third age.

(Thirteenth of the rearing of the silkworm.)

This day about fifty-two pounds and a half of chopped leaves will be sufficient. The decrease of food is consequent upon the diminution of appetite already mentioned; many of the worms are already torpid.

They should have four meals; the largest first, and the last the least meal. Those only that seem to require it, should be fed.

Should a great number of silkworms on one table be torpid, while others continue to require food, these should be given a slight meal, without waiting for the stated hour of their feeding, to satisfy them, that they may sink into torpor quickly.

Fifth day of the third age.

(Fourteenth of the rearing of the silkworm.)

This day twenty-seven pounds of picked leaves, chopped, will be about the quantity; if it is not enough, more may be added: if too much, less given.

These two last days, the silkworms begin to cast about some silk down.

The insect seeks free space to slumber in dry and solitary spots, rearing its head upwards, which is known by finding it on the edges of the paper, where any stalks stick up, upon which it retires. All of them not being able thus to separate from each other, are obliged to remain upon their litter, but testify uneasiness by rearing up their heads.

When on the point of sinking into torpor, they completely void all excremental matter, and there remains in their intestinal tube, a yellow lymph alone, rather transparent, and which supplies almost all the animal fluid in them. This is that which, before the surface of the skin they are about to cast, becomes wrinkled and dry, causes them to appear of a yellowish white color, like amber, and semi-transparent.

When the worms prepare for the third, and even the fourth moultings, the air of the apartment should be gently agitated, but the temperature must not be much varied. This may be done by opening the ventilators in the ceiling, and those in the floor.

Sixth day of the third age.

(Fifteenth of the rearing of the silkworm.)

On this day the silkworms begin to rouse, and thus accomplish the third age.

The general view of this age presents the following result: In six days the silkworm goes through its third age. In this age, those worms proceeding from five ounces of eggs, have consumed nearly 300 pounds of leaves and young shoots.

The muzzle of the silkworm during the third age, has maintained a reddish ash color, and is no longer shining and black, as it appears in the two first ages, but it is lengthened and more prominent. The head and body are much enlarged since the casting of the skin, even before they have eaten at all: proving that they were straitened in the skin they have cast, and being now unconfined, the air alone has expanded their bulk. This growth, which is considerable, is more visible in this age than in the preceding.

When this age is completed, the body of the silkworm is more wrinkled, particularly about the head; they are of a yellowish white, or rather fawn color, and to the naked eye they have no appearance of hairiness. In this third age, we first hear, when the worms are fed, a little hissing noise, similar to that of green wood burning. This noise does not proceed from the action of the jaws, but from the motion of the feet, which they are continually moving: this noise is such, that, in a large laboratory, it sounds like a soft shower of rain; by degrees, when the worms fasten to their food, the noise ceases. The average length of the silkworms, which was six lines after the second moulting, is become, in less than seven days, above twelve lines. The weight of the insect has increased fourfold in the same period.

It has been sufficient, during this age, to open the ventilator, the door, and even the windows, when the weather was still and fine, so as to lower the temperature by a degree only. In damp, close days, a small wood fire, in the fire-place, renews the air, by drawing a current, without injuring the interior atmosphere. During this age, it never happened that the exterior temperature, although higher than the interior, went beyond the prescribed limits.

4. REARING OF THF SILKWORM IN THE FOURTH AGE.

In this age, the worms proceeding from five ounces of eggs, should occupy a space of about 412 square feet; the temperature should be from 68° to 71°. In this fourth age, as in the fifth, there will probably be days in which it will not be possible to maintain the temperature of 71°, because of the heat of the weather as the season advances; and in spite of artificial means it may very probably rise to 73° or upwards.

This augmentation of temperature does no harm. It is sufficient that the circulation of air be not interrupted. The moment it is per-

ceived that the exterior atmosphere begins to heat the laboratory, the ventilators should be opened, as well as all apertures on the side exposed to the sun. In the space of two hours, some of my laboratories have been observed to rise from 71° to 80°. All the apertures were then opened, and the air being stagnant, some faggot wood was burnt in the fire-place, to establish a complete current of air, and thus change the air of all the rooms thoroughly. If instead of thus acting when the heat of the season ceases suddenly, (which augments the fermentation of the litter,) we should exclude the exterior air from the laboratory, we may chance to lose whole broods of silkworms; because, as they grow, the mass of leaves and litter increasing, the dampness proceeding from it will more quickly produce fermentation, the heat would also augment, and the air would soon be not only moist but pestilential.

As before said, the silkworms should not be lifted off the hurdles, after they have completed their third age, until they are nearly all well roused; because, should the first roused have to wait a day and a half, it will not hurt them. Those early roused should be put in the coolest part of the apartment, and the late roused worms in the warmest part. If this should be troublesome, it may suffice to give the latest roused worms more space, by keeping them farther asunder, and they will soon come up to the others. It is easy to tell, by the thermometers, which parts are constantly the hottest, and this knowledge will serve to render all the silkworms even sized. All this care is indispensable, if the worms are required to draw their silk equally, and at the same period, particularly as there accrue great evils when some of the silkworms rise too much above the others. It is after the third moulting that the silkworms should be moved into the large laboratory, in which they are to remain until the end. The space of this large laboratory should contain at least 917 square feet of wicker hurdles or tables. Experience constantly demonstrates the advantage of having buildings proportionate to what is required of them, as much on account of economy of fuel, if the season be cold, as the convenience of attendance. There would certainly be no great objection should there be two or three small contiguous buildings, instead of one large laboratory, so that they afforded an equal space. The only advantage that would thus be lost, would be the great facility enjoyed in a spacious building, of establishing and maintaining constant and regular currents of air. It must here be repeated how advantageous to the art of rearing silkworms is the practice of distributing them in regular strips and squares, which should be extended and widened, and gradually filled with these insects, as they accomplish their various ages.

2d. Because the leaf distributed upon evenly proportioned spaces, is entirely eaten before it is withered and spoilt.

3d. Because, by this practice, the worms can feed with facility, move with ease, and breathe more freely: all decisive advantages for these insects.

We must forego these advantages when the worms lie too thick. In that condition they cover the surface so closely, that the leaves on which they lie are wasted, as they cannot possibly eat them; while, on the contrary, when they have a plenty of room, they seek, in moving, every atom of the leaf, and eat it up. Besides, when straitened, the action of their breathing tubes is hindered, and confined by the pressure, either superior or lateral, of one worm against the other; whilst, when in full space, the action of their respiratory organs is free, which materially contributes to their health.

First day of the fourth age.

(Sixteenth of the rearing of the silkworm.)

On this day 37½ pounds of the young shoots will be needed, and 60 pounds of picked leaves coarsely chopped with a large blade.

When the moment of removing the worms from the hurdles comes, one or two hurdles only at a time should be covered over with young shoots. These shoots, loaded with worms, are afterwards put upon portable trays and removed, as in the first moultings. Should there not be a sufficiency of small boughs, branches of 15 or 20 leaves, tied together by the stalks, will answer the purpose. The stiffer these leaves the better they remove the worms, and with less inconvenience are they carried. This removal must be performed by two or three persons; one to fill the portable trays, or two to carry them, and one who will gently remove the silkworms from these trays upon the hurdles in the space allotted for them. In this manner it can be executed with ease and promptitude The strips into which are arranged the silkworms upon the hurdles, should occupy about half the space of them.

It has been mentioned that the worms that are to occupy 174 feet of hurdles must be placed in the middle of a space of about 412 feet 6 inches square.*

When all the silkworms that are revived have been successively removed, there remain still some upon the 174 feet of hurdle, torpid, that have not the strength to climb upon the shoots or branches of leaves.

The early roused worms being removed into the great laboratory, if they have eaten all the leaves on the young shoots and leaves that served to carry them, and they remain without food, they should then be given thirty pounds of leaves chopped a little: with these the intervals between the young shoots must be filled, and the strips formed into regular order, by sweeping into their place any boughs or leaves that are scattered irregularly.

After this second meal, those worms that were heaped together will be seen stretching out evenly. The other thirty pounds of leaves

* It is important here again to caution the cultivator against giving the worms branches or twigs with the fruit on them. If the worms eat the fruit they will become sick, and besides the litter is greatly increased by not picking the leaves clean.

should not be given until the second meal has been consumed; and should the young shoots and leaves not be required, they may be given the next day.

Although it is not a general custom to chop or cut the leaves for silkworms, in this fourth age, it has been found very beneficial to give it to them, coarsely cut up; fresh leaves, slightly cut up, by exhaling a stronger smell, stimulate their hunger, and the cut edges are more easy to bite.

The late roused silkworms should be placed on hurdles, distinct from the earliest worms.

At the end of this day, the worms begin to show some vigor; they move quickly to the leaves; they grow perceptibly, lose their ugly colors, become slightly white, and assume more decided animal action.

When all the silkworms are taken out of the small laboratory, the hurdles from which they have been removed should be well cleaned. This should be done quickly, if any of the silkworms are to be put into the small laboratory again for the convenience of space.

Second day of the fourth age.

(Seventeenth of the rearing of the silkworm.)

For this day will be wanted 165 pounds of sorted leaves, slightly cut up. The two first meals should be the lightest, and the last most copious.

The worms grow fast, and their skins continue to whiten.

In giving the meals, the space occupied by the worms should be widened.

Third day of the fourth age.

(Eighteenth of the rearing of the silkworm.)

For this day will be needed 225 pounds of sorted leaves, a little cut. The two first meals ought to be the most plentiful; the last meal to be of about 75 pounds.

Fourth day of the fourth age.

(Nineteenth of the rearing of the silkworm.)

This day the distribution of the cut leaves should be 255 pounds; the three first meals of about 75 pounds each; the fourth of 45 pounds only. The worms still get whiter, and at this time are more than an inch and a half long.

Fifth day of the fourth age.

(Twentieth of the rearing of the silkworm.)

No more than 128 pounds of picked leaves will be needed this day; because the silkworm's hunger diminishes much. The first meal should

be the most considerable. A great number of the worms become torpid on this day.

The leaves should only be distributed as they are wanted, and only on those hurdles where the worms are perceived not to be torpid, that they should not be wasted uselessly. The worms are this day an inch and three-quarters long.

Sixth day of the fourth age.

(Twenty-first of the rearing of the silkworm.)

Thirty-five pounds of picked leaves are enough for this day. It is easy to find out where, and in what quantities, the worms need feed.

Since the preceding day, the silkworms begin to decrease in size, as they have cleansed and cleared themselves of all nutritive substances, before they sink into their torpor.

The greenish color of the rings of their body has disappeared, and their skin is quite wrinkled.

Seventh day of the fourth age.

(Twenty-second of the rearing of the silkworm.)

The silkworms rouse in this day, and accomplish their fourth age. In generalizing this paragraph, let us suggest the following observations:*

In about seven days, the worms have accomplished their fourth moulting, and cast their skins.

They have consumed, in that period, 207 pounds of leaves for each ounce of eggs.

In the seven days of the fourth age, the worms which were about one inch long, have grown half an inch in length. In this age, their weight is augmented fourfold.

After the third moulting, 144 insects weighed one ounce; it now requires only 35 to make up the ounce.

After this moulting they are of a darker color: grayish, with a red cast.

During this age, shavings of wood should be burnt in the fire-places three or four times a day; dry straw will answer the purpose also, as this is done to renew and lighten the air of the room, without particularly heating it; should it be necessary to heat the laboratory, that should be done either with the stove, or by burning large wood in the fire-places.

* Mr. Stephenson directs, that "as soon as several of the worms have passed their fourth moulting, all those which rouse during the two first days should be put on one hurdle, those of the next two days on another, that each parcel may be carried on as equally as possible. This remark may be useful to those who depend upon the precarious temperature of the air, and do not use a stove. According to the system of Dandolo, the whole period will occupy only two days.

When straw or shavings are burnt, the ventilator should be opened for the circulation of the air. If the exterior temperature be not cold, and the weather calm, the doors and windows may also be opened; when the interior temperature by these means is lowered half a degree, the windows and doors should again be closed, leaving the ventilators open, and the temperature will rise again. Those who have Venetian blinds to the windows, should open the windows to allow the air to enter. Persons who attend silkworms should breathe as freely in the great laboratory as in the open air; they should feel no difference but that in the heat of the interior temperature, and the latter in temperature, not in the closeness. Therefore, should the air appear heavy, the fire of straw or shavings ought to be lighted, to renew the air, which is done in a moment. In the laboratories described, the interior air is more pleasant than the exterior air, from the delightful smell of the mulberry leaves.

In proceeding in the manner detailed, the silkworms will breathe continually a pure and dry atmosphere, which makes them healthy.

CHAPTER IX.

OF THE REARING OF THE SILKWORMS IN THE FIRST PERIOD OF THE FIFTH AGE, OR UNTIL THE MOMENT WHEN THEY PREPARE TO RISE ON THE HEDGES.

The fifth age of the silkworm is the longest, and most decisive. Previously, therefore, to resuming the description of the daily progress of the silkworms, a few practical observations will be given.

Should the worms die in the first age, the loss is trifling, because expense is not prolonged; while, on the contrary, should the worms perish in the fifth age, the loss is considerable, leaves having been consumed, labor paid for, and other expenses incurred; besides seeing the hopes of all that profit vanish, which had been reckoned upon.

It is then very needful to know the condition of the worms in the fifth age, to learn how to manage, so as to ensure their health and strength against the effects of a bad atmosphere, or other evils that assail them.

As the silkworms grow in the fifth age, they are liable to three evils, which attack them according to their strength, and to their distribution in the laboratory, and may weaken them so as to cause their speedy destruction. These are, 1st. the great quantity of fluid disengaged from the insects, their dung, leaves and litter. 2. The damp hot atmosphere of the laboratory. These causes of disease, and the means of preventing them, shall be treated of in the chapter on the diseases of silkworms.

OF THE REARING OF SILKWORMS UNTIL THE APPROACH OF THEIR MATURITY.

The worms have now approached the time when they prepare to rise, and when they reject the food which they had lately so voraciously devoured.

First day of the fifth age.

(Twenty-third of the rearing of the silkworm.)

Since the preceding day, almost all the silkworms must have accomplished their fourth moulting, or casting of skin, and be already roused.

The laboratory should have uniformly 68° or 69½° of heat. The silkworms proceeding from five ounces of eggs, until the termination of their fifth age, should occupy 917 feet of trays, or 183 feet 5 inches for each ounce of eggs.

The silkworms proceeding from one ounce of eggs in the fifth age, consume about 1,098 pounds of sorted, picked leaves, which makes the quantity of leaves required by the five ounces to be 5,490 pounds weight.

After the fourth moulting, the food should consist of the full grown leaves of the oldest trees: for the appetite of the worms is great, and they require the strongest nourishment to strengthen them, and to promote their growth. Their last feed should be given late at night, or just before going to bed, and as early as possible in the morning.* To facilitate their removal, branches to which the leaves are attached, may be given.

As soon as the branches are loaded with worms, they should be taken off, and put upon the little portable trays. If the silkworms of one wicker tray are almost all roused, they will be sufficient to fill the space of rather more than two wicker trays; and there should be formed a space in the middle of the two wicker trays, of about half the width of the tray.

When five hundred and eight square feet are filled, the trays that are left empty should be cleaned. The hurdles must be cleaned every two days during the fifth age.†

If, in cleaning, any worms should be found roused, by putting some shoots or leaves, they may be taken off, like the others; should some rouse after this, they may be taken up with the hand, and put with the others; but if any remain still in torpor, they must be cast away.

The sheets of paper with the litter must be rolled up, as was done in the former age, and poured into the basket prepared for this, which is to be carried out at once.

In observing the litter when it is removed into a dry place, should some roused worms be found in it, they may be placed distinct from

* Stephenson.

† Nyster, page 107

the others, in the warmest parts of the laboratory, with more space, that they may thrive faster, and be even with the early worms. The worms should cover rather more than half the space allotted to them. Of the six persons, required to perform this task, one or two of the most handy and neat should be directed to lift and put the silkworms on the portable trays; two should carry them, and one should remove and place them on the wicker, while the others roll the papers and litter, clean the hurdles, and carry out the dirt.

If it is judged necessary, another person may be employed in distributing shoots to the later silkworms, which are but just rousing, that all things may proceed without bustle or confusion.

Should it be deemed advisable to divide the operation of cleaning and removing, it may be done by cleaning only half the wickers in the morning, and the other half in the evening; in which case, the worms whose changing is deferred to the evening, must have one or two meals given them; yet changing them all at once, and it may be done in four hours, when the worm is steady, is deemed preferable.

The ninety pounds of shoots and leaves on which the silkworms were removed, furnish them with an abundant meal: the other ninety pounds of sorted leaves should be divided into two meals, which should be given them every six hours. In giving the first meal, straighten the lines of the strips on the hurdles, by sweeping any straggling leaves or worms into regular order. At the third meal the strips should be widened a little. Should there be too many worms in some parts, they should be taken to cover the barer parts of the wickers.

The silkworms appear tolerably strong this first day.

If the exterior temperature be mild, and little different from that of the laboratory, it might be left open while cleaning, to admit, on all sides, a free current of air. Shavings must also be burned to make a blaze; this is particularly necessary, when the cold or dampness of the weather precludes opening all the apertures of the laboratory while cleaning. In cases of cold and high winds, the upper and lower ventilators may be kept open, which will renew the air as much as the blaze; and, in all cases, the thermometer and hygrometer must positively regulate all proceeding by their indications.

Second day of the fifth age.

(Twenty-fourth of the rearing of the silk worm.)

For this day will be wanted two hundred and seventy pounds of leaves, sorted, divided into four feeds; the first, which should be the least, of about fifty-two pounds, and the last, which is the most plentiful, of ninety-seven pounds weight.

In distributing the food, the strips should be widened gradually.

At the close of this day the worms are much whiter and considerably developed.

Third day of the fifth age.

(Twenty-fifth of the rearing of the silkworm.)

This day the silkworms will require about 420 pounds of sorted leaves. The first feed should be of 77 pounds; the last feed should be the largest, and of about 120 pounds weight.

The worms continue to whiten, and many appear upwards of two inches long.

They could eat, on this day, a larger quantity than specified; but it is thought most beneficial not to add to this quantity, that they may thoroughly digest it; besides which, this treatment strengthens their constitution, and makes them livelier. The strips they occupy should be widened, whenever they are fed.

Fourth day of the fifth age.

(Twenty-sixth of the rearing of the silkworm.)

This day the silkworms will want five hundred and forty pounds weight of sorted leaves; the first feed should be of one hundred and twenty pounds weight, and the last of one hundred and fifty.

The worms now are beginning to grow voracious and stronger; some are two inches and a half long.

Fifth day of the fifth age.

(Twenty-seventh of the rearing of the silkworm.)

The worms will this day want eight hundred and ten pounds of picked leaves; the first feed of one hundred and fifty pounds, and the last meal of two hundred and ten pounds weight.

If necessary, the silkworms should have some intermediate food; when the regular distribution of leaves is devoured in less than an hour and a half, the worms must not be suffered to fast five hours, but receive some leaves in the interim; particularly if there should have been wickers on which the worms had not been as well fed as the others at first; for although the quantity of food for this day has been fixed, it is always necessary to be regulated by experience. Should the worms want more food, they must have it.

In the course of the fifth age, the wicker trays should be cleaned. If the litter is dry and fresh, they need not be shifted till the evening of this day, or the beginning of the second day; but this must depend on circumstances, and the convenience of the cultivator. Care must be taken in distributing the last meal on this day, only to feed four wicker trays at a time, to allow of time insensibly to lift off the silkworms before they have finished eating the leaves given them. As this time the worms are not to be removed, the wickers must be cleaned after another manner. The following is the manner of cleaning them:

The portable trays are put on the edges of the wickers, and when the leaves are loaded with silkworms, they are put in single layers on the portable trays. When several of these are filled, the litter, with or without the sheets of paper, must be carried off in square baskets, which are hung near the wicker trays; the litter being removed, the paper should be swept and cleaned with light brooms; the sheets of paper are laid down again, one after another, and the leaves, with the worms, replaced on them. This is repeated until the litter has been entirely changed throughout the laboratory.

Upon a small scale, the shelves or hurdles may be cleaned by placing a line of fresh chopped leaves the whole length of the hurdles, near the worms, which will immediately attach themselves thereto. They may then be taken up by means of the leaves and stalks they cling to, and be removed to another hurdle or shelf, when the litter they have made can be swept away, and removed from the room.

When one basket is full, it is carried out, and another substituted. Great care should be taken not to hurt or bruise the worms in removing them. Six persons, at least, should be employed to perform this cleaning of the litter expeditiously, and in their number are not included those who carry the litter out.

The silkworms that have been cleaned should be fed, and those that are to be cleaned last, may be fed before they are cleaned, that none of them may fast too long.

It must not be forgotten that, during this period, as the case may require, there should be light blazing fires burnt; the fumigating bottle* should also be passed twice round in the laboratory, and the windows and ventilators opened according to the state of the exterior atmosphere; but, in all cases, the ventilators in the ceiling and floor, and all the doors, must be open. If the exterior air be very damp, the small blazing fires may be frequently repeated; and if they raise the temperature too much, it may easily be lowered by opening the ventilators and windows, being guided by the thermometer and hygrometer.*

Sixth day of the fifth age.

(Twenty-eighth of the rearing of the silkworm.)

The silkworms should have 975 pounds of picked leaves, divided into five feeds; the last of which should be the most plentiful. The silkworms now eat most voraciously.

If, after having distributed the leaves, the quantity appears insufficient upon some wickers, and it has been devoured in an hour, an intermediate meal should be added.

Knowing the quantity of leaves to be given in the day, it is easy to distribute them either into four or five meals, as it may appear to suit the silkworms best. If the wickers could not be all cleaned in the preceding day, the operation may be finished this day.

* See the chapter on the diseases of silkworms.

Some of the worms are now three inches long, and are become whiter; to the touch they present a soft velvety surface, and are strong and healthy. By giving more food to the worms last removed from the hurdles, and by allowing them more space, they will soon equal the earliest in size.

Seventh day of the fifth age.

(Twenty-ninth of the rearing of the silkworm.)

The silkworms will require this day 900 pounds weight of well sorted leaves. The first meal should be the largest, and those following should diminish; should there be any intermediate meals wanted, they must be given as before.

Some worms will now be seen upwards of three inches long. The extremity of the insect begins to grow shining and yellowish, which shows they are approaching to maturity.

Some of them begin to eat with less voracity. They this day attain their largest size, and their greatest weight. On an average, six silkworms now weigh an ounce. Thus their weight has increased five-fold in seven days since the fourth moulting, at which time thirty-three silkworms made an ounce.

Eighth day of the fifth age.

(Thirtieth of the rearing of the silkworm.)

The silkworms this day must have 660 pounds of well sorted leaves. The proportion of leaves must diminish, as the appetite of the worms decreases much. The food must, as usual, be divided into four messes; give them the largest meals first, and gradually diminish. The first meal of 210 pounds of leaves.

That the maturity of the worms may be perfectly alike, some intermediate food should be given according to necessity, to bring on those worms that are backward.

During the last days of the rearing of the silkworms, they should be fed with the best sort of leaves, always culled from the oldest trees.

The silkworms now advance towards maturity, which may be perceived by their yellow color, which increases from ring to ring. Their backs begin to shine, and the rings lose their dark green color. The advance to maturity is also denoted in some of them, by the diminution of their bulk in the course of this day; and by their seeking to fix themselves to the edge of the hurdles to avoid the substances with which they are loaded.

This day, and more or less speedily, according as the signs of maturity increase, and that the litter becomes moist, the wickers should be cleaned in the manner before described, being very careful to take the worms gently with the leaves upon which they lie, that they may not be bruised. Light fires, and fumigate with the bottle, to purify

the air; the ventilators, and the use of the thermometer and hygrometer are, in this change of litter, more essential than on any former change.*

Ninth day of the fifth age.

(Thirty-first of the rearing of the silkworm.)

The silkworms this day need 495 pounds of leaves, which must be distributed as it may be wanted.

The yellow hue of the silkworms grows deeper, their backs shine more, and, in some of them, the rings assume a golden appearance. The muzzle is become of a brighter red than it was in the beginning.

From time to time, a gentle fire should be lighted, particularly in the night; twice a day the fumigating bottle should be passed through the laboratory; the ventilators should never be shut when the fire is lighted, nor indeed at all, that the air may be renewed entirely.

Although the silkworms reared according to the methods described, have been exposed to every variation of seasons, and to many accidents that might have proved injurious to them, they have still been found to preserve their full health and vigor.

It has already been said, that, should it be impossible, from the heat of the season, to keep the temperature at the degree fixed, it must be as nearly kept as may be possible, by using all means of cooling the air, and causing a free circulation in the laboratory. The preservation of the proper temperature of the apartment, at this stage of the worm, cannot be too seriously impressed upon the cultivator. If sudden and great heat in the weather should take place, as often happens at this time, serious loss may be suffered without proper precautions. The increased heat to which the worms are exposed, causes them to cease eating, to leave their feeding shelves, and to wander about the room in order to find corners and places to form their cocoons, before the silk fluid has been fully elaborated or matured; thus defeating, in a great measure, all the care previously bestowed upon them. To guard against a sudden heat in the weather, the window shudders must be closed while the sun is beating on them, the ventilators in the ceiling, or other parts of the room, kept open, and, if possible, tubs of ice should be brought into the apartment, until the thermometer shows a diminution of temperature to the proper degree. The windows must also be opened every evening until sunrise next morning, and water sprinkled on the floor to promote evaporation, and, consequently, a freshness in the air. Under the head of the diseases of silkworms, it will be seen that great heat in the weather, at this stage, will even kill the worms. The effects described above, of a sudden increase of heat in the weather, which continued three days, were seen exemplified last summer, upon the worms in a large establishment, by the writer.

* It must be borne in mind, that the directions of Mr. Dandolo, constantly refer to a large laboratory, in which worms, the produce of five ounces of eggs, are rearing. When the air of the apartment is sufficiently pure, and the temperature properly regulated by the thermometer, there will be no necessity for fires, unless in damp weather, nor for fumigations.

CHAPTER X.

OF THE REARING OF THE SILKWORMS IN THE LAST PERIOD OF THE FIFTH AGE; THAT IS TO SAY, UNTIL THE COCOON IS PERFECTED.

Observations on the subject.

The fifth age can only be looked on as terminated when the cocoon is perfect.

The cleanliness of the tables in these last days of the fifth age, requires great attention to preserve the health of the silkworms.

It must be added, that, if the quantity of leaves ordered for the tenth and last day of the fifth age be insufficient, a very little more should be allowed them; for they should now be stinted, even if there chance to be some leaves left. And also, should the worms take eleven days, instead of ten, to come to perfection, the same quantity might suffice. There are causes we cannot trace, which hasten or slacken the progress of the silkworms towards maturity by some hours.*

Tenth day of the fifth age.

(Thirty-second of the rearing of the silkworm.)

Matured perfection of the Silkworm.

This last day they attain perfection, which may be ascertained by the following indications:

1st. When, on putting some leaves on the wickers, the insects get upon the leaves without eating them, and rear their heads as if in search of something else.

2d. When, on looking at them horizontally, the light shines through them, and they appear of a whitish yellow transparent color.

3d. When numbers of the worms which were fastened to the inside of the edges of the wickers, and straightened, now get upon the edges, and move slowly along, instinct urging them to seek change of place.

4th. When numbers of worms leave the centre of the wickers and try to reach the edges, and crawl up upon them.

5th. When their rings draw in, and their greenish color changes to a deep golden hue.

6th. When their skins become wrinkled about the neck, and their bodies have more softness to the touch than heretofore, and feel like soft dough.

* The American cultivator must attend to this caution. The worms should be fed four or five times a day at this time, and no more leaves given them than they can eat. If too many leaves are given, they will dung on them, and, besides, increase the trouble of cleaning the hurdles.

7th. When, in taking a silkworm in the hand, and looking through it, the whole body has assumed the transparency of a ripe yellow plum. When these signs appear in any of the insects, every thing should be prepared for their rising, that those worms which are ready to rise may not lose their strength and silk in seeking for the support they require.

First preparation for forming the Hedge or Espalier.

A week or ten days before the worms are ready to mount, bundles of twigs of chestnut, hickory, oak, or of the birch of which stable brooms are made, must be procured and prepared.

These should be arranged into bunches, that the worms may easily climb up them, and fix themselves conveniently to pour out their first downy silk, and then work their cocoons. These bushes should be neither too thick set nor too bare. As soon as it is observed that the worms want to rise, the faggots should be put up against the inside wall, above the wicker trays, on the most convenient side, leaving fifteen inches between each bundle.

The twigs or top branches of the bundles should touch the lower part of the tray above that on which they are placed, and, by being bent down by the tray above, form a species of arch, upon which we must observe:

1st. That the bundles should be placed a little aslant, so that the worms that climb up may not drop off.

2d. That they should be longer than the height between the floor and the wicker hurdles, or than the height between the lower wicker and that above; thus they form a curve when placed between them, and in this manner the worms that rise upon the curving part, do not soil the worms that are climbing perpendicularly under them, when they evacuate, which would be the case were the arch not made.

3d. That the branches should be spread out like fans, that the air may penetrate through all parts, and the worms may work with ease. When the worms are too near each other they do not work so well, and form double cocoons, which are only worth half single cocoons. This inattention, which is almost universal, causes great loss every year, which is little known, except by the manufacturers who spin the silk, who are obliged to separate the double cocoons from the single—the silk being of an inferior quality.

The bundles should be fixed into the wicker work of the hurdles and not into the paper, which requires only to lift the paper at the edge of the wicker, to put in the ends of the faggots through the wicker, so as to let them touch the edges. This arrangement is also convenient for the cleaning of the hurdles, which must soon occur.

Mr. Stephenson directs that openings should be left at the tops of the curves, because the worms always make choice of them to form their cocoons. Another advantage arises from these openings, viz: that the cabins will contain a greater number of worms than when these vacancies are small. The very small tender shoots must also be cut off, as they are not able to carry the weight of a worm, and might

occasion the loss of many of them by their tumbling off. The lowest shelf should project three inches on each side, beyond the one next above it, and the same difference must be made in all the other shelves progressively upwards, in order to receive the worms which may fall from the shelf above. These projections should be covered with brush, to break their fall: for the same reason brush should be placed on the bottoms and entrances of the cabins, to afford places for the worms to form cocoons, in case they should be stunned by falling, and disabled from again mounting on the branches.

Having thus placed upon each hurdle, and in their angles a sufficient number of spreading bundles, the first worms that are ready easily find their way up. If, in the course of this day, (which requires the very utmost care,) in watching the hurdles, some worms should be perceived ready to rise, they must be taken up and put near the ends of the bushes. There should be also some dry twigs of oak, or other wood, put upon the wickers, and when the worms rise on them, they may be lifted and put close to the bushes, which will save the trouble of constantly looking for the worms that are ready to rise.

It must be observed, however, on this subject, that, during the first three or four hours on which the silkworms give signs of rising, it is not necessary to be in a hurry to make them climb up; for, by remaining some hours on the hurdles, they have time to cleanse themselves by evacuation upon the litter.

Whatever may be the method followed in the course of this period, it is always desirable that the little bundles of twigs should be well placed, well arched, clean and light, and not thick; that, as before said, the air may circulate freely, and that the worms may work with ease in them.*

Last feed to be given to the Silkworms.

The 240 pounds of sorted leaves which are still in reserve, should be given by degrees, and according to their wants. The little appetite of the silkworms, and their wish to rise upon the leaves, prove that, even were they given more food at one time, it would only add to the litter which would become dirty, because this is the period at which they evacuate most. From this it is better rather to stint them in each distribution.

The hours of feeding cannot be fixed in this last day; it cannot even be known, whether there may not be required a small quantity of leaves for the following day.

Cleaning of the hurdles; end of the preparations for the rising of the Silkworms.

As soon as the worms are prepared to rise, the hurdles should be

* Instead of bushes, Messrs. Terhoven, of Philadelphia county, use frames for the worms to form their cocoons in. See plate 2d. fig. 4, and the explanation of them.

cleaned thoroughly. This operation, although tedious, is easy enough, with the aid of the portable trays.

These portable trays cannot now be put on the hurdles, because the cabins placed round them prevent it; however, they may be supported against the trays, so as to be able to use them within. When they are placed near the trays, the ripe worms must be carefully put upon them. Two or three portable trays should be filled. This done, the litter should be emptied from the sheets of paper into baskets.

When one portion of the hurdles has been cleaned, the paper is to be replaced, and the worms gently slided down upon it by slanting the tray. Upon a small scale, the fully ripe worms may be picked one by one, and placed on the cabins, when they will immediately mount. Mr. Stephenson directs to place them at first in the middle of the cabin; if the sides are begun with, or the outer ends of the cabins, it will be difficult to supply the middle with worms, without disturbing, and even destroying some of those which are mounting on the sides, in reaching in with the hand towards the middle.

They should, strictly, only be given the quantity of food they may want, and that very sparingly. When the baskets are filled with litter, they must be directly carried out of the laboratory. In this manner, several persons may clean the hurdles in a few hours. The silkworms, when put on the portable trays, should be handled with the greatest gentleness and ease, leaving them on the twigs or bits of leaves to which they are fastened, not to hurt them in tearing them off. The slightest injury, at this age, is particularly hurtful to them, because the vital action is much diminished.

In sliding the silkworms upon the hurdles, they should be placed in squares of about two feet, beginning on the side upon which the espalier or hedge is already placed, and forming the squares close to them, so that the silkworm may find no difficulty in rising: a distance of eight or ten inches must be left between the squares.

In the centre of these squares should be fixed bunches of small dry boughs. This operation may be performed by eight persons in eight hours.

During the time of this operation, the exterior air should be freely admitted on all sides, and may be drawn in by lighting a blazing light fire in the chimneys.

All the ventilators should be open, as well as the doors and windows, if there be no wind, and if the weather be not much below the 68th degree of temperature, which is the prescribed heat of the laboratory. Although, generally, the air at this time of the year is neither cold nor windy enough to be obliged to shut up the laboratory, it becomes necessary to take great precaution in admitting air. In such cases, a part only of the ventilators should be opened at once. The fumigating bottle should also be passed once or twice through the laboratory, and the hygrometer will show whether the air is grown sufficiently dry.

During this time the worms continue to rise and climb, and thus it is indispensable to finish the hedge, and to fill the hurdles with rows

of cabins. The first row of inside bundles of twigs should be placed at six or eight inches distance from one another, to form the hedge; other small bushes must be stuck in between them, and form a species of vaulted roof under the higher hurdle; it should not be too thick; the small bushes may be stuck into the lower hurdle without taking off the paper. Across the middle of the hurdle, and between the squares into which the silkworms have been laid, should be stuck four twigs in a bunch, and spread out like a fan, to admit the air, and that the silkworms may be able to rise and climb into every part of them to make their cocoons. When the hedge is formed round three sides of the wicker hurdles, and the groups or bunches of twigs are placed in the centre of them, the worms should, with great care, be put nearer the hedge, that they may climb with ease. The cabins should be about two feet from one another, and will hold a great quantity of silkworms.

As soon as the hedge and bunches are nearly laden with worms, other small twigs should be put between the hedge and bunches, and between those bunches and the outside edge of the wicker trays. Thus are formed parallel hedges across the wicker trays, at two feet distance, and as all the top branches wave and bend under the wicker trays above, or the ceiling, the whole presents an appearance of small avenues covered in at top, and shut in at the end of the hedge, and are called "*cabanes*," or huts.

This arrangement of cabins will generally suffice to receive all the silkworms of a wicker hurdle: should there, however, remain some silkworms on the tray when the cabins are nearly laden, a small branch may be put against them, and thus prevent their lying too thick together on the hedges. If care has been taken to provide long sweeping twigs, well curved at the top, and well spread out, that the air may pass through them, the number mentioned will be found quite sufficient to answer all purposes, and the silkworms will, with ease, work well, not huddle together, and will not touch one another, and not produce double instead of single cocoons.

Two essential things should always be attended to. The first is, to put those worms near the cabins which are perceived to be ready to rise; and the second is, to give a few leaves to those worms that are still inclined to eat. One or two careful persons should be thus occupied.

As long as the worms feel a wish to eat, were it only one mouthful, they will not think of their cocoon, and it will happen, that, after climbing, and even evacuating themselves, they sometimes go down again for more food; they will also sometimes stop when descending, and remain with their heads downward—the wish to eat having ceased before they reached the bottom; they should then be turned, so that their heads may be put upwards, as the down position is injurious to them.

These attentions which appear too frivolous, often contribute, however, to an abundant crop of the best cocoons, with few double ones.

Separation of the Silkworms which will not rise: cleaning the wicker hurdles for the last time.

Four-and-twenty or thirty hours after the worms have first begun to rise, and when four-fifths have risen, there remain on the wickers those that are weak and lazy, which do not eat, do not seem of the disposition of those that have risen, but remain motionless on the leaves, without giving any sign of rising. These should be taken away, and put either in the small laboratory, or in any dry clean room of at least 73° of heat, where there are hurdles covered with dry clean paper, and the hedge ready preparéd for them.

As soon as they are thus placed, some will rise directly; others will eat and then rise, and so on till all will have risen. These worms will have acquired the vigor and stimulus they wanted, by being put in a warmer and much drier apartment.

The great mass of silkworms in the large laboratory, in evacuating themselves, often soil one another, which will destroy their vigor, and indispose them to rise; the best remedy is to remove them at once to a dry and tolerably warm place.

Should these worms be very numerous, not only should there be the hedge round the hurdles, but also the clump and hedge across, that they may have every facility for rising offered to them.

If only a part of these worms appear inclined to rise, they should be covered with some leaves and some twigs put over them, that, when they climb upon these, they may be taken in the hand, and put upon the cabins, as they are then ready to rise.

With this assistance, the lazy worms will distribute themselves in the branches, evaçuate, and begin weaving cocoons.

Before these few worms are put on the cabins, we may form a sort of support or couch of wheat or rye straw for them among the branches, to prevent their dropping off, and to give them time to fasten themselves to the branches. In this manner have been attained cocoons from almost every silkworm.

All the silkworms being off the hurdles, having either risen or been carried away, no time should be lost in cleaning the hurdles, which must be done with the greatest expedition.

Care of the Laboratory until the Silkworm has completed its fifth age.

1st. When the worms manifest a desire to rise, infinite care should be taken to prevent the temperature of the laboratory from falling: [or rising:] it should be maintained between 68° and 71° by means of the ventilators in the ceiling and floor, which must be opened more or less, according to circumstances; and the air may be circulated from the contiguous apartments, by opening the doors into them.

It is proved that any violent agitation of air cramps the worms, stunts them, causes them to drop off, and suspend the work they had begun.

2d. When the worms are near rising, the air should be kept as dry as possible, that the paper on the wicker may dry when it is wet with the moisure of the evacuations; and that the vapor which exhales from the body of the insect, may be absorbed and carried off: the quantity of this is very considerable.

3d. Should any of the worms drop off that had risen, they should be taken up, and carried into the apartment where the other later worms were put, to prevent the late worms from weaving in the large laboratory, when the early ones have finished their cocoons.

4th. When the silkworm has cast out the down which precedes the silk, and it has just begun to wind its cocoon, as the air does not then directly strike upon them, the air may be freely admitted now and then.

5th. When the cocoon has acquired a certain consistency, the laboratory may be left quite open, without fearing the variations of the atmosphere. The tissue of the cocoon is so close, that the agitation of the air, far from being detrimental to the silkworms, agrees with them, even if it should be colder than the temperature fixes for the laboratory.

Mr. Stephenson directs that all diseased and dead worms should be removed immediately, as the first will infect the healthy worms, and the last, by causing a bad smell, would annoy those which are at work in making their cocoons.

Although it may seem needless to those who inhabit warm climates, that such minute details should have been gone into, yet, as in an elementary work, rules should be laid down applicable to all cases and to all places, in the art of which it treats—the endeavor has been made to speak of every circumstance that might occur, and to provide for it. All the care hitherto recommended, has tended—

1st. To preserve the silk, contained in the reservoirs of the silkworms, in a constantly fluid state.

2d. To keep the skin or surface of the silkworm sufficiently dry, and constantly in the degree of contraction necessary, and without which the silkworm would perish.

3d. To prevent the air from ever being corrupt, and which might make the silkworm ill, or suffocate it, at those very periods when it most needs its highest vigor to pour out all the silk it contains.

If these rules are not observed with exactitude, there is danger of the accidents occurring which it may be useful here to state.

1st. Too cold or agitated an air, introduced into the laboratory, may instantly harden, more or less, the silky substance of those worms on which it may blow. This substance thus not being fit to pass through the silk-spinning tubes, the insect is soon obliged to cease drawing out its cocoon, and suffers. Then will many of those worms that are not sufficiently wrapt in the silk, be liable to drop off at any moment, and lessen the abundance of cocoons.

2d. Too damp an atmosphere, preventing the contraction of the skin of the worms, which enables it to evacuate itself, and to exude the silk through the silk-drawing tubes, causes them to suffer, weakens

them, slackens their work, and gives them numerous disorders, which cannot easily be defined.

3d. An atmosphere vitiated by the fermentation of leaves and dirt, or by the later worms that lie on the litter, as well as by the defect of circulation in the interior air, which renders the breathing of these insects difficult, relaxes their organs, and also causes various diseases among them. In such cases, many worms drop off, others form bad cocoons, die within them when they are finished, and are spoiled.

4th. A case of very rare occurrence here, but which must be noted to complete the views on this subject, is, too warm and dry an atmosphere, which dries up the worms, producing too violent a contraction of the skin, not proportioned to the vacuum which increases in the animal by the slow pouring out of the silky substance, and by transpiration; and thus forces them to violent and fatiguing action in the formation of the cocoon; in which case they employ the reservoirs of silk too fast, forcing the silk drawing tubes, producing coarser silk, which thus never can have that fineness which it possesses when produced in a temperature of 69°. Having tried to expose a number of silkworms to very dry air, at 100 degrees of temperature, several thousand feet of the coarse downy flos, or bave, were obtained from the cocoons by the common method of spinning; the weight of this flos being six times greater than the flos obtained from cocoons formed in a temperature of 69°.

This observation may explain why the silk produced in very hot climates is stronger and less fine than that produced in temperate regions, where the silkworms are reared at a lower degree of temperature.*

The fifth age is accomplished, when the silkworm pours out its silk and forms the cocoon.

The fifth age is perfected, when, on touching the cocoon, it appears to have obtained a certain consistency. The silkworm has then cast its envelope, is changed into the chrysalis, and has entered its sixth age.

Quantity of vapor and excremental substance emitted by Silkworms, from the time they reach their full growth, until the formation of the cocoon.

The calculation resulting from facts, will here be offered, by which may be ascertained the quantity of substance which issues from the silkworm towards the close of the fifth age, that this calculation may show the evils which are constantly likely to attack a laboratory.

* The above remark applies to the East India silk, the inferiority of which will be noticed hereafter, in an extract from the Minutes of the Evidence taken before a Committee of the British Parliament on the Silk Trade.

Count Dandolo has omitted a very important caution, which it is essential to attend to when the worms begin to spin their cocoons. It is to preserve the utmost silence in the apartment, as the worms are very sensible to the least noise, and, if disturbed, will for a moment, cease to spin. Thus the continuity of the thread will be interrupted, and the value of the cocoon greatly diminished.

In the space of six or seven days, the bodies of the insects requisite to produce only 600 pounds of cocoons, must have lost 700 pounds weight of vapor, or gas, solid and liquid excremental substance. This astonishing quantity of substance, execrated from the bodies of the silkworms in so short a time, is of greater weight than the total weight of the cocoons and chrysalis, which only weigh 600 pounds, It is scarcely credible that the bodies of the silkworms should yield so much noxious matter in a few days, were it not demonstrated by positive facts.

This large body of exhalation, were it stagnant in the laboratory, might, in the later days, generate disorders quickly, and cause great mortality at the very moment when the abundant crop of the cocoons was most confidently expected. We must, therefore, feel the deep necessity of attentively following the prescribed directions for avoiding this evil.

CHAPTER XI.

OF THE SIXTH AGE OF THE SILKWORMS, OR OF THE CHRYSALIS; GATHERING AND PRESERVATION OF THE COCOON.

The sixth age begins in the chrysalis state, and ends when the moths appear, having left their shell in the cocoon that covered them.

The following are the necessary things that remain to be done:

1. To gather the cocoons.
2. To choose the cocoons which are to be preserved for the eggs or seed.
3. Preservation of cocoons until the appearance of the moth; we shall then treat of
4. The daily loss of weight which the cocoons suffer from the time they are finished until the appearance of the moth.

1. *Gathering of the cocoons.*

Strong, healthy, and well managed silkworms, will complete their cocoons in three days and a half at farthest, reckoning from the moment when they first begin casting the flos. This period will be shorter if the silkworms spin the silk in a higher temperature than that which has been indicated, and in very dry air.

It is also more or less prolonged, if the silkworms are not well and healthy, or if they are exposed to a colder temperature than has been fixed: if they are exposed to transitions of heat and cold, to damp and vitiated air, or to draughts of wind, before the cocoon is sufficiently advanced to shelter them entirely; and, in short, if a great number of silkworms rise long after the first have risen, which is always the consequence of bad management and want of care.

To avoid the losses which any slight inattention may have occasioned, it will be better not to take off the cocoons before the eighth or ninth day, reckoning from the time when the silkworms first rose. They may be taken off on the seventh, if the laboratories have been conducted with such regularity that the time may be known with certainty when this may be done.

Begin on the lower tier of hurdles, and take the cabins down gently, giving them to those who are to gather the cocoons. Place a basket between two of the gatherers, to receive the cocoons; another person should receive the stripped bushes, which may be laid by for another year. All the cocoons that want a certain consistency, and feel soft, should be laid aside, that they may not be mixed with better. Empty the baskets upon hurdles or trays, placed in rows, and spread the cocoons about four fingers deep, or nearly to the top of the wicker tray. When the cocoons are detached, the down or flos, in which the silkworms have formed the cocoon, should be taken off. If the cocoons are for sale, weigh them, and send them to the purchaser. The baskets, the floor, and all things used, should be cleaned.

Pullein directs, when gathering the cocoons, to make four assortments. 1. Those designed for breed. 2. The dupions. 3. The firmest of those which are to be reeled. 4. Those of a looser texture.

2. *Choosing the cocoons for the production of eggs.*

About two ounces of eggs may be saved out of one pound and a half of male and female cocoons.

The small cocoons, of a straw color, with hard ends and fine webs, and which are a little depressed in the middle, as if tightened by a ring or circle, are to be preferred. There are no certain signs to distinguish the male from the female cocoons: the best known are the following:

The small cocoons; sharper at one or both ends, and depressed in the middle, generally produce the male; the round full cocoon, without ring or depression in the middle, usually contains the female. These, according to Pullein, may be distinguished from the dupions by the extra size, the clumsy shape, rather round than oval, of the latter. As, however, all marks may fail, an extra number may be kept of the best of those which are spun double, and when the moths come out, the males and females being easily distinguished, an addition can be made from them to the defective side.

By shaking the cocoon close to the ear, we may generally ascertain whether the chrysalis be alive. If it be dead, and loosened from the cocoon, it yields a sharp sound; when dead, it yields a dumb muffled sound, and is more confined in the cocoon.*

Sauvage says, that the dupions, or double cocoons, constantly produce a moth of each sex; and, on this account, advises them to be selected for seed; but it is a mistake to suppose that this equality in the sexes of the dupions takes place, for Mr. Nysten found, that of 20 double cocoons which he examined, seven contained two males; six, two females; and seven, one male and one female.†

* Cours d'Agriculture, vol. 9, p. 599.
† Recherches sur des Vers a Soie, p. 168.

3. *Preservation of cocoons intended for seed.*

Experience shows that where the temperature of the room is above 73°, the transition of the chrysalis to the moth state, would be too rapid, and the coupling will not be productive. If below 66°, the development of the moth is tardy, which is also injurious. Damp air will change it into a weak and sickly moth. The apartment should, therefore, be kept in an even dry temperature, between 66° and 73°. When collected, spread the cocoons on a dry floor, or on tables, and strip them clean of down or flos, to prevent the feet of the moth being entangled in it when coming out: while cleaning them, all those that appear to have any defect should be laid aside: this is the time, also, to separate the male and female cocoons, as far as we can distinguish them.

Mr. Stephenson directs the selection of an equal number of males and females, and to keep the cocoons of the same day's mounting separate, that the moths may pierce them at the same time. If the good cocoons, taken from the whole parcel, are all first mixed, and the selection for those intended for breeding be made from this general heap, many will be set aside, which were formed by worms that had mounted upon different days, and which will be pierced by the moths unequally, and hence there will not be an equal number of males and females produced at the same time. This irregular appearance may cause the loss of a great many moths or of several thousand eggs. Pullein orders the choice to be made from those shelves, or arbors in which the worms spun the earliest. But it is questionable, whether the circumstance of early spinning, would affect the worm next season, unless the temperature of the apartment in both seasons was equal. Dandolo says, that the strength shown by a worm in forming a cocoon, has no influence upon the fecundity of the male, nor upon the quality of the eggs. Cocoons of various tenuity and shapes, have equally afforded him large quantities of well-impregnated eggs. Healthy worms, of equal weights, have given cocoons which varied in weight.

When the selection has been made, the sorted cocoons must be put on tables, in layers of about two inches, allowing the air to pass freely through them, that it may not be necessary to stir them frequently; but it is beneficial to stir them round once a day if the air be moist. When the seed cocoons are not very numerous, they may be strung upon threads and hung against a wall, or suspended from a beam. Just so much of the middle of the cocoon is to be pierced with a needle as is sufficient to attach it to the thread. The middle is chosen, because it cannot be ascertained at which end the moth will pierce the cocoon. Place a male and female, alternately, upon the thread, that they may be near each other when they come out.*

If the heat of the apartment is above 73°, every method of diminishing the heat should be tried; such as keeping all apertures to the sunny sides carefully closed, to cause thorough draughts of air to dry the

* Stephenson.

humidity that exhales from the chrysalides. Should the temperature rise to 78° or 82°, the cocoons must be put into a cooler place, as a dry cellar.

4. *Daily loss in weight of cocoons, from the time of their formation till the moth escapes from them.*

It is a common opinion that the weight of the cocoon, after diminishing, increases for a certain period. This old error induces persons to give their cocoons too soon to the spinner, before they lose their weight, or too late, when they keep them back, in hope they will soon recover weight. The following is the result of the decrease of 1,000 cocoons, in a temperature of between 71° and 73°.

Gathered from the cabins and cleaned, the cocoons weighed - - - - - - -	1,000 ounces.
First day following - - - - -	991
Tenth day - - - - - - -	925

The decrease in weight was gradual, but not regular. The cocoons lose, in ten days, seven and a half per cent. by the drying of the chrysalis alone. The four first days, they lose three per cent. in the the last days, they lose rather more.

It is a loss for the purchasers of cocoons to receive those that are of different ages, because, when in some cocoons the moth is preparing to come forth, and other cocoons are not so forward, the spinners are at a loss whether to let it come directly, or to kill the chrysalis to preserve the cocoon.* If the rules which have been recommended are exactly followed, this loss will be avoided, and the cocoons will be perfectly formed, and ready to be reeled off at the end of seven days, reckoning from the day they first rose upon the bushes or frames.

Great care must be taken to preserve cocoons from ants, which will destroy them as certainly as they do the silkworm.

CHAPTER XII.

SEVENTH AGE OF THE SILKWORM.

Birth and coupling of the moth; of laying the eggs, and the preservation of the eggs.

This seventh and the last age of the silkworm, comprises the entire life of the moth.

*In making a contract, therefore, in the early part of the season for cocoons, the cultivator should attend to the above points.

The formation of the moth, and its disposition to issue from the cocoon, may be ascertained, when one of its extremities is perceived to be wet, which is the part occupied by the head of the moth. A few hours after, and sometimes in one hour after, the moth will pierce the cocoon and come out. Occasionally, the cocoon is so hard, and so wound in silk, that the moth in vain strives to come forth, and dies in the cocoon. Sometimes the female deposites some eggs in the cocoon before she can get out, and often perishes in it. This circumstance has induced some to extract the chrysalis from the cocoon by cutting it, that the moth may only have to pierce its thin envelope. But Dandolo disapproves of the practice, (although he has performed the operation with success,) because it is tedious; and should the moths be put on a plain surface, five in a hundred will not be able to get out, but will drag the envelope along, and at last die, not being able to disencumber themselves. If the surface be not smooth, the moths will issue with greater ease. It is very favorable to the moths when they put forth their head and first legs, to find some substance to which they may fasten, and thus facilitate clearing out of the cocoon by the support; for this reason they should be spread out very thin on tables, covered with a muslin or linen cloth. The life of the moth lasts, in Italy, ten, eleven, or twelve days, according to the strength of its constitution, and the mildness of the atmosphere. With Mr. Dusar, of Philadelphia, the moths lived from five to eight days. A hot temperature accelerates their operations, and the drying which precedes their death.

Hatching of the moths, and their preservation.

Cocoons, kept in a temperature of 66°, begin to be hatched after fifteen days; those kept in a heat between 71°, and 73°, begin to come forth after eleven or twelve days. The room in which the moths are produced should be dark, or at least there should be only sufficient light to distinguish objects. This is an important rule, and must be carefully attended to. The moths do not come forth in great numbers the first or the second day: they are chiefly hatched on the fourth, fifth, sixth, and seventh days, according to the degree of heat of the place in which the cocoons are kept. The hours when the moths burst the cocoons in greatest number, are the three and four hours after sunrise, if the temperature be from 64° to 66°. The male moths, the very moment they come out, go eagerly in quest of the female: when they are united, they must be placed on trays covered with linen, and made in such a manner as to allow it to be changed when soiled. Much care must be taken in raising the united moths. They must be held by the wings, in order not to separate them: if this happens, they must be replaced on the tables of the moths of their own sex. When one small table is filled with moths in a state of union, they are to be carried into a small room, sufficiently airy and fresh, and which can be made very dark. Having employed the first hours of the day in selecting and carrying the united moths, the males and females which are found se-

parate on the tables, are to be brought into contact, put on other frames and carried into a dark room. It is easy to ascertain if there are more females than males. The body of the female is nearly double the size of that of the male; besides, the male which is single, beats about its wings at the least approach of light. The hour must be noted, at which the tables containing the united moths were placed in the dark room. If, after this operation is over, there still remain some moths of each sex, they are to be placed in the small perforated box, plate 1, fig. 4, until the moment favorable for their union arrives. From time to time they must be looked at, to see if they separate, in order that they may be brought anew into contact. When any thing is to be done in the dark chamber, as little light as possible must be admitted, only sufficient to distinguish objects. The more light there is, the more the moths are disturbed and troubled in their operations, as light is too stimulating for them. The boxes are very convenient to keep quiet the males which remain, and thus prevent the fine powder adhering to their wings from flying about, and the destruction of their wings, and consequently, the loss of their vital power. The cocoons must be removed as fast as they are pierced by the moth; for being moist, they communicate their humidity to those which are still entire. The paper, also, on the trays, when soiled, is to be removed, and fresh supplied. Constant attention is required during the whole day, as there is a succession in the process of hatching and union of the moths, which occasionally vary in relative proportion to one another. Instead of a frame, paper may be used for the purpose of receiving the eggs. A few good cocoons will not produce a moth, owing to their hardness, which prevents the moth from making a hole by which to come forth.

2. *Separation of the moth, and laying the eggs.*

If there be an excess of males, they must be thrown away; if of females, males must be allotted to them, which have already been in a state of union. Great care must be taken, when the couples are separated, not to injure the males. The male ought not to remain united more than six hours. After the lapse of that time, take the moth by the wings and the body, and separate them gently. All the males which are no longer in union must be placed upon the frames; the most vigorous are afterwards selected, and united with those females which have not yet had a mate. Other vigorous males must be preserved in a separate box, and kept in darkness. When there is likely to be a want of males, let them remain united to the female, the first time only five hours instead of six. The females are not injured by waiting for the male, even many hours; the only loss sustained is that of some eggs which are not impregnated. Six hours, as just said, is the usual time for the moths to remain united; for, in that time, the eggs of the female will be fully impregnated. It is also the general practice not to use the male for another female; but Mr. Delonchamps, already quoted, assures us that, in the event of having more female than male

moths, the latter may be again used to profit. In the year 1824, he raised many worms from eggs the produce of a sixth coupling, which were fully equal to those produced from eggs at the first. The union continued never less than from twenty to twenty-four hours. The male, after a sixth union, appeared as lively and as brisk as at first, but he had no more females. The eggs from even a thirteenth union of the same male with different females, had all the characters of those of the best quality. In these cases the disunion of the pair was, moreover, never spontaneous, but always required to be effected by the hands.* Before separating the sexes, prepare, in a cool, dry, airy chamber, the linen on which the moth is to deposite its eggs. The following is the manner in which the cloth must be arranged:

At the bottom of the tressel, plate 1, fig. 5, which must be about four feet seven inches high, and three feet eight inches long, place, horizontally, on each side of the length, two boards, so arranged that one of their sides should be nailed to the tressel, about five inches and a half high above the ground, and that the other side of the board shall be a little higher, and project outwards, Upon the tressel lay a cloth, so that it may hang equally on each side. The ends of the cloth must cover the boards below. The more perpendicular the lateral parts of the tressel are, the less soiled will be the cloth, by the evacuation of the liquid that comes from the moths. The moths which have been united six hours, are then to be gently separated, the females placed on the frame, and carried to the tressel and placed on the cloth, one over another, beginning at the top, and going downwards. Note the time at which the moths are placed on the cloth, taking care to keep those which are placed afterwards separate, to avoid confusion. The females that have had a virgin mate must be treated in the same manner as those which have been united with one that had been coupled previously five hours. The females should be left on the cloth 36 or 40 hours, without being touched. At this time, if it be observed that the linen has not been well stocked with eggs, other females must be placed on it, in order that the eggs may be equally distributed. When the heat of the room is 77° or 79°, or when at 63° or 65°, the eggs will be yellow, that is, unimpregnated, or of a reddish color, that is, imperfectly impregnated, and will not produce worms. The temperature of the room must therefore be kept between these extremes. Sometimes a female moth will escape from its mate before impregnation, and produce many useless eggs. Mr. Swayne remarks, "that he had a cocoon of an orange color given to him, the moth of which happened to be a female. From this, by coupling with a straw-colored mate, were propagated all that he had of an orange color. Hence he concludes, that the color of the silk depends chiefly upon the female."†

* Essai sur L'Histoire, &c. p. 69. Should others have the same success as this author, many cocoons containing males which are preserved for seed, may be used for winding, and comparatively a smaller number than females be kept for coupling. He thinks that one-sixteenth part of males, in a parcel of cocoons, would be sufficient. The experiment of repeated unions should be made.

† Trans. Soc. Arts, London, vol. 7, p. 144.

If this should be found a fact, we may have a rule whereby to avoid the orange-colored breed, which are not approved of, by choosing for eggs those female cocoons which are of a straw or white hue. The female cocoons, as before noted, are generally larger than the males, and not so much pointed as they are, and are without the ring or depression in the middle, which commonly distinguishes the cocoons containing the latter.

Eight or ten days after the deposition of the eggs, the jonquil color peculiar to them, will change to a reddish gray, and afterwards into a pale clay hue. They are of a lenticular form, and on both surfaces there is a slight depression.

3. *Preservation of the eggs.*

Collect the eggs which have fallen on the cloth covering the shelves of the tressel, and put them in a box, in layers not more than half the breadth of the finger. The cloths raised from the tressel when quite dry, are to be folded and placed in a dry room, the temperature of which does not exceed 65°, nor below the freezing point, 32°. If water does not freeze in the room, in a dish, leave the cloths there until spring.

During the summer, the cloths must be examined, to remove insects. To preserve the cloths always in fresh air, place them on a frame of cord, (plate 1, fig. 6,) which should be attached to the ceiling, and inspect them every month.

There exists a notion that, every two or three years, the eggs should be changed. It requires little to be said on this egregious error. To suppose that the good cocoons of a cultivator, after a few years are no longer fit to produce good seed, and yet that these cocoons can give good seed for the use of another, would be to admit a superstitious contradiction, which reason, practice, and science, alike condemn. A change of seed can alone be necessary, when, from great neglect for a series of years of the worms, a diminutive race has been produced. Worms, properly treated, will never degenerate. "Good keep will always produce good worms."* On the subject of the degeneracy of silkworms in the United States, the most positive information can be given.

Mr. Samuel Alexander, of Philadelphia, says: "From my own observation, I am convinced that silkworms, cultivated in Pennsylvania, instead of degenerating, improve; proof of which I possess, in comparing the cocoon of four years since, with those of the last year. I can say with truth, the worms hatched from the eggs I brought from the South of Europe, have produced annually better silk."† The testimony of Mr. Sharrod McCall, of Gadsden county, Florida, is still more decisive. A sample of beautiful sewing silk, sent with his com-

* Mr. Russel Falley, of Ohio: Letter in answer to the silk circular.
† Letter in reply to ditto.

munication to the Secretary of the Treasury, was part of a parcel produced by worms, the stock of which he has had thirty years, and they were obtained from a maternal ancestor, who had possessed them many years before. During all this long period, no degeneracy has been observed. *Let proper care be taken of silkworms, and no deterioration will take place.* The time has passed when the idle reveries of Buffon, Robertson, De Pauw, and others, respecting the tendency of nature, "to belittle" and degenerate every thing foreign in the new world, were received as truths. Facts, proud facts, demonstrate not only the gross absurdity of their positions, but the superiority of every American animal and vegetable, when compared with similar productions in the old world.

CHAPTER XIII.

GENERAL VIEW OF ALL THE FACTS STATED IN THIS WORK, IMMEDIATELY CONNECTED WITH THE ART OF CULTIVATING SILKWORMS.

In Italy, according to Dandolo, to compose an ounce of eggs of the largest breed of silkworms of four casts, it will require 37,440. If all these eggs produced a worm, and all the worms should live, about 373 lbs. of cocoons would be obtained; because 150 cocoons weigh about one pound and a half.

For an ounce of eggs, of common sized worms, 39,168 will be required, and will yield 162 lbs. of cocoons: for about 360 cocoons weigh a pound and a half.

For an ounce of eggs of worms of three casts, it will require 42,200 eggs, which will yield 105 lbs. cocoons: for 600 weigh a pound and a half.

From these facts it may be ascertained, by the quantity of cocoons obtained, how many eggs have failed, and how many have died of various ages; it will afterwards be of use in determining which method of rearing the worms is most favorable to their preservation. Thirty-nine thousand silkworms, proceeding from one ounce of eggs, can eat the first day, and lie easily in a space of about twenty inches square.

Space occupied by worms in different ages.

The worms proceeding from an ounce of eggs, should have a space.
In the first age, of seven feet four inches square.
In the second age, of fourteen feet eight inches square.
In the third age, of thirty-four feet ten inches square.
In the fourth age, of eighty-two feet six inches square.
In the fifth age, of one hundred and eighty-three feet four inches square.

It may be regarded as a general rule, that the worms ought not to touch one another.

Quantity of leaves consumed by Silkworms in their different ages.

The result of a most exact calculation is, that the quantity of leaves drawn from the tree, employed for each ounce of eggs, amounts to 1,609 lbs. 8 ounces, divided in the following manner:

First age, sorted leaves		- - -	6 lbs.
Second age,	do	- - -	18
Third age,	do	- - -	60
Fourth age,	do	- - -	180
Fifth age,	do	- -	1,098
	Picked leaves	-	1,362

Two hundred and forty pounds eight ounces weight, lost in refuse picked from the leaves, and by evaporation, make up the gross weight.

Facts relative to the cocoons containing the healthy chrysalis: diseased chrysalides, and dead chrysalides.

When the cocoons are perfectly formed, they diminish, in the four first days, three quarters per cent. each day; the other days, the diminution is very trifling.

Seven and a half pounds of cocoons, containing healthy chrysalides, yield eighteen ounces of pure cocoons; which will give eight ounces of silk when spun. This proportion of silk to cocoons, may vary according to the ill or good management of the worms. In the unfavorable year 1814, Dandolo obtained fifteen ounces of silk from seven and a half pounds cocoons, and thirteen ounces from the same quantity of refuse cocoons: we find one pound of coarse flos to nineteen of cocoons that can be spun, and four ounces of flos to eleven ounces of spun silk.

About 506 feet of the single thread, or fibre of silk from worms of three casts, weigh one grain.

The cocoon of this worm yields $2\frac{304}{1000}$ grains of silk; and, if we make an average calculation, we shall extract about 11 ounces of silk from 3,000 cocoons, weighing $7\frac{1}{2}$ pounds. The same cocoon yields 1,166 feet long of the single fibre. In an ounce of this spun silk will be found a length of 291,456 feet.

The cocoon of the worm of four casts, yields $3\frac{84}{100}$ grains of silk, because there are about 11 ounces of spun silk drawn from 1800 cocoons, weighing $7\frac{1}{2}$ pounds. This cocoon yields 1760 feet of spun silk; 421 feet 8 inches of silk from a cocoon of a worm of four casts weigh a grain: 11 ounces of silk are drawn, on an average, from 750 cocoons, weighing $7\frac{1}{2}$ lbs. This cocoon consequently gives about 3,885 feet of spun silk; an ounce of this silk is 242,880 feet long. In this are not included the first down taken off the cocoon, nor the flos.

We may conclude, that the silkworm, in forming this cocoon, draws a thread of half a mile in length.*

It requires 12,860 cocoons, with healthy chrysalides, to weigh 1000 ounces.

Seven pounds and a half of "calcined worms" contain about 44 ounces of pure cocoons. As these cocoons yield about 12 ounces of spun silk, out of 21 ounces of pure cocoons, it is evident, that from 500 ounces of pure cocoons, may be drawn—

In spun silk, about - - - -	$28\frac{1}{2}$ oz.
Coarse flos - - - - -	$21\frac{1}{2}$
	50

Seven pounds and a half of stained cocoons, containing calcined chrysalides, that is, 120 ounces, contain about 50 ounces of pure cocoons; but, as in stained cocoons, there is always a part of the substance spoilt, the spinner cannot foretel whether from seven pounds and a half of cocoons, he will obtain one-half of the quantity that the healthy cocoons would yield him; the less the silk, the greater will be the proportion of coarse flos, and the flos is worth less than the cocoons of the healthy chrysalis; one thousand of these stained cocoons weigh a pound and a half.

Generally, it is not possible to separate the decayed chrysalis from the cocoon, the worm being turned into a black soapy substance, sticking to the inside of the cocoon, sometimes the mummy is black, and sometimes detached. A part of these cocoons may be spun; but the silk is never so fine as that from healthy cocoons. Eight hundred and sixty of these cocoons weigh a pound and a half.

Facts relative to the production of eggs.

Three hundred and sixty cocoons, of the finest quality, weigh about 25 ounces. If we suppose half of these to be females, these will be about 180. Each impregnated moth will lay, on an average, 510 eggs. This number is equivalent to $7\frac{1}{2}$ grains, as 68 eggs weigh a grain. The 180 female moths, consequently, lay 91,800 eggs, which weigh 1,350 grains, or about two ounces and one-third. If the 91,800 eggs yielded an equal number of silkworms, and if well managed, and they each formed a cocoon, we should obtain 382 lbs. 8 ounces of cocoons, which the following year would yield eggs sufficient to produce 97,537 lbs. 8 ounces.† Bonafous says,‡ that 14 ounces of cocoons will produce, on an average, an ounce of eggs. According to Pullein, a hundred pair of moths will produce about an ounce.

* In the Abbe Rosier's Cours d'Agriculture, it is stated that one single thread, forming a whole cocoon, is three miles long.

† Dandolo. ‡ De L'Education des Vers a Soie, p. 85.

Quantities of silk yielded by various parcels of cocoons.

Eight pounds of cocoons, (16 oz. to the pound,) of the finest quality, produced from 16 to 18½ ounces of silk.

Eight pounds of the finest quality produced from 16 to 18½ ounces of raw silk—6 to 9 cocoons per thread.

Eleven pounds produced from 19 to 21½ oz. avoirdupois, from 6 to 9 cocoons per thread; another parcel, same weight, gave the same quantity of silk.

55 lbs. of the second quality, produced 109 ounces of raw silk.

55 lbs. of the first quality, 12 to 16 cocoons, produced 117⅞ ounces avoirdupois, which is about 16 per cent. less than the last parcel.

15 lbs. green cocoons, best quality, produce	-	20¾ oz.
20 lbs. second quality, (not well sorted,) -	-	24
15 lbs. best green cocoons, produced -	-	20¾
10 lbs. second quality, - - - -	-	13⅛
11 lbs. best cocoons, produced - - -	-	44*

150 ounces (Italian, 28 oz. to the lb.) will yield 11 oz.† the thread of from 5 to 6 cocoons.

12 lbs. cocoons, 3,300, will make 16 ounces of silk, and 8 ounces of flos.‡

Mrs. Williams§ obtained nearly one ounce and a half from 244 cocoons. Miss Rhodes‖ had, on an average, one ounce from 360 cocoons, not including flos, and eleven ounces from 4,000 worms. She says that Mrs. W. included the flos in her product: had Miss R. done so, twenty-five instead of eleven ounces might have been had. Thirty thousand produced five pounds avoirdupois. If troy weight had been used, 21,600 would only have been required. One thousand two hundred and seventy, gave her nearly four ounces of silk. Two thousand eight hundred and ninety-three, produced exactly half a pound of silk, and somewhat more than a quarter of a pound of waste silk, or tow: on an average, 360 cocoons yielded an ounce. Mr. Swayne calculates, from the produce of 50 cocoons reared by him, that 13,405 would have yielded five pounds of raw silk.¶ Twelve thousand produced 5 lbs.**

10 or 11 lbs. (French, 12 oz. to the lb.) are required to make one pound of silk thread, called tram, of from 8 to 20 fibres: 13 lbs. made one pound of organzine.††

15 or 16 lbs. gave one pound of silk.‡‡

15 lbs. yielded one pound and a half silk, according to Dandolo.

* From Habersham's MS. Journal of the silk culture in Georgia.

† Trans. Amer. Phil. Soc. vol. 2, p. 366.

‡ Pullein, p. 182.

§ Trans. Soc. Arts, London, vol. 2, p. 154.

‖ Trans. Soc. Arts, London, vol. 4, p. 149.

¶ Trans. Soc. Arts, London, vol. 10, p. 181.

** Trans Soc. Arts, London, vol. 8, p 165. The secret of this great production, for which the cultivator, Bertezen, an Italian, received the premium offered by the Society, was never divulged.

†† Delonchamps, Essai, &c. p. 77.

‡‡ Delalauze, Traite, &c. p. 290

8 lbs. from well managed worms, gave one pound and a quarter of silk* in France. Twelve pounds produced the same quantity of silk, in another house.

5 lbs. gave one pound at Varese, in Italy.†

10 killogrammes, (22 lbs. Amer.) gave one killogramme of silk—(2 lbs. 3 ozs. 5 d. avoirdupois.)

12 killogrammes (26½ lbs. Amer.) of cocoons of a good quality, give one K. of organzine, of four or five cocoons. Inferior cocoons will require 14 K. to produce the same weight.

For a K. of fine silk, of nine or ten cocoons, 11 K. of fine cocoons, and 13 K. of the second quality will be required.

To make a K. of tram silk, 9 to 11 K. (24¼ lbs. Amer.) of cocoons, are required, according to their quality.‡

Mr. Chasel, in the Isle of France, obtained 180 ounces, (French) from 55,000 cocoons.

The estimates of the number of worms to make a pound of silk, are as various as the proportions of cocoons to the same quantity of silk. The difference in both cases may proceed from the different sizes of the worms, and the greater or less care in feeding them. Mr. Storrs, of Connecticut, says that 4,000, and Mr. Tufts, of Massachusetts, that 3,000, are required to make a pound. Mr. Falley, of Ohio, estimates that 5,000 are requisite.

Weights of cocoons.—Produce of cocoons, and of silk from an ounce of eggs.

Mr. Stephenson says, that 220 cocoons, tolerably good, weigh a pound French. Three thousand cocoons of the worm of three casts, weigh 7½ pounds French, according to Dandolo.

In France, from 45 to 50 killogrammes of cocoons, (90 to 100 lbs.) are expected from one ounce of eggs, carefully hatched and worms well fed and attended. An ounce of eggs consists of about 40,000, half of which commonly are lost from sickness in the worms.§

Two hundred cocoons from worms reared in the early settlement of Georgia, weighed one pound.‖

At Washita, 240 cocoons, from worms reared by Judge Bry, weighed one pound.¶

Three thousand three hundred cocoons weighed twelve pounds.**

In one establishment in France, 262 cocoons, in another 267, in a third 271, and in a fourth 328 cocoons, weighed a pound of twelve ounces.

These different results proceeded from diversities in the treatment.††

* Stephenson, Trans. Soc. Arts, London, vol. 43.
† J. Murray, Treatise on Silkworms, Edinb. 1826.
‡ Reynaud, p. 140.
§ Reynaud p. 358.
‖ MS. Journal of the Rev. Mr. Boltzius of Ebenezer, vol. 3, p. 855.
¶ Letter in answer to the silk circular.
** Pullein, p. 181.
†† Nysten, page 71.

In Tuscany, 150 cocoons, from large worms, in a favorable year, and 208 in a bad year, weigh a pound of 12 ounces.

One hundred and ninety-five cocoons from small worms, (pestallini) in a favorable year, and two hundred and seventy-one in a bad year, weigh a pound.*

In Pensylvania, 306 cocoons, from worms fed by the late Mr. Busti,† and from 490 to 600 in the establishment of Messrs. Terhoeven, weighed a pound.

Eight hundred and eighty-two clean cocoons, from worms fed entirely on the leaves of the native red mulberry tree, by Mr. Joshua Pierce, of Washington City, weighed a pound, six months after they were formed.

An ounce of eggs will produce from 30 to 40 pounds of cocoons, according to Mr. Delalauze‡ in France.

Mr. Stephenson says that, in Languedoc, one quintal of cocoons, (104 Amer.) will yield from nine to ten pounds of spun silk; and that from five to ten pounds of silk is the produce of an ounce of eggs: five pounds are deemed a fair return.

Four cocoons from imported eggs, the worms fed by Mr. Dusar, of Philadelphia, weighed each, with the flos, 24½, 31½, 26½, and 28½ grains, troy.

Proportion of eggs to cocoons.

In an establishment in France, where from 10 to 12 ounces of eggs were for 22 years regularly hatched, each ounce produced from 63 to 95 pounds of cocoons, once only 63. In another, in which six ounces were annually hatched, during ten years, each ounce produced constantly a quintal of cocoons.§ In Italy, according to Dandolo, the average yield is only 45 lbs., but he adds that 120 lbs. should be the produce. In another part, Novara, of the same kingdom, 100 lbs., and at Varese, from 50 to 60 lbs. were obtained.‖ In Tuscany, every pound of eggs, (the pound reduced to nearly 12 oz.) yielded 100 lbs., in the establishment of Lambruschini.¶ Dandolo says, that one pound and a half of male and female cocoons will yield two ounces of eggs. Sauvage** estimates the proportion of cocoons from an ounce of eggs producing 40,000 worms, to be from 50 to 100 lbs. of cocoons; the chance of success being in an increase ratio to the proportion of eggs. One hundred pounds of cocoons will be produced from one ounce, while only 60 pounds will be the yield of one ounce, when ten ounces are hatched together. This difference must certainly result from the want of room for the worms proceeding from the larger quantity, and

* Trans. Georgophile Soc. of Florence, vol. 4, p. 411.
† Memoirs Phila. Soc. for the Prom. Agric. vol. 5, p. 266.
‡ Traite sur des Vers a Soie, p. 290.
§ Nysten, Recherches sur la Maladies des Vers a Soie, p. 111.
‖ Murray on the Silkworm, Edinb. 1826.
¶ Atti della Soc. &c.—or Trans. of the Georgophile Soc. Florence, vol. 4, p. 411.
** First Memoir, p. 52.

from the greater ease with which an ounce can be attended to while hatching, than ten ounces. This reasoning applies also to the worms while feeding.

Proportion of different qualities of cocoons, in various parcels, before and after being baked.

The following facts, on this subject, are taken from the MS. Journal left by Mr. James Habersham,* on the progress of the silk culture in Georgia, while a colony.

	lbs.	*oz.*
50 lbs. of green (unbaked) cocoons produced, of the first quality, hard and weighty - - -	27	00
of the second quality a little woolly -	10	04
of dupions, or double balls, - -	12	12
27 lbs. 2 oz. of green cocoons produced, of the first quality,	18	08
second quality,	5	02
dupions	3	08
18 lbs. 8 oz. of the first quality, weighed after being cured,	16	02
5 lbs. 2 oz. second do. - - -	4	06
3 lbs. 8 oz. dupions - - -	3	00
7 lbs. $3\frac{1}{8}$ oz. of cocoons produced, of the first quality,	5	$01\frac{3}{8}$
second do -	1	$08\frac{7}{8}$
dupions -	0	09

Cocoons weighed after being cured.

18 lbs. 8 oz. of the first quality weighed - -	16	02
5 lbs. 2 oz. second do - - -	4	06
3 lbs. 8 oz. dupions - - -	3	00

Mr. Habersham found, "by sundry experiments, that cocoons lost by curing, twelve per cent., in weight. They were weighed forty-eight hours, or less, after being taken out of the oven.

The following calculation of the labor attending and connected with the culture of silk, in Connecticut, is by John Fitch, Esq. of Mansfield, Connecticut.†

One acre of full grown trees, set one and a half rods apart, will produce forty pounds of silk.

The labor may be estimated as follows:

For the three first weeks after the worms are hatched, one woman, who is acquainted with the business, or children who would be equal to such a person.

For the next twelve or fourteen days, five hands, or what would be equal to five, if performed by children. In this period, two men, with other help, would be employed to better advantage, than all women and children. This period finishes with the worms.

* President of the Council of Georgia.

† Letter to the Hon. John Baldwin, Member of the House of Representatives, January 17, 1829.

For picking off the balls, and reeling the silk, it will require about the same amount of labor, for the same length of time as the last mentioned period, which may all be performed by women and children. The aforesaid labor and the board may be estimated at eighty dollars, spinning the silk at thirty-four dollars; forty pounds of silk, at the lowest cash price, is now worth two hundred dollars—which makes the following result:

40 lbs. silk at $ 5 per pound - -		$ 200 00
Labor and board - -	$ 80	
Spinning - - - -	34	
		114 00
Nett profit per acre - - -		$ 64 00

The principal part of the labor may be performed by women and children. But where the business is carried on to a considerable extent, it is considered more profitable to employ some men for the last period of the worms.

AN ABSTRACT AND CONDENSED VIEW OF THE MODE OF REARING SILKWORMS.

Procure eggs in February and March, and choose those of a pale slate, or clay color; avoid all which are yellow, as they are imperfect. Keep them in a cold dry place, (where water will, however, not freeze,) until the leaf-buds of the mulberry begin to swell. If the eggs be soiled, dip the paper or cloth to which they adhere, in water, once or twice, to wash off the coat with which they are covered, and which will impede the hatching of the worms. Dry them quickly in a draught of air, and put them in one or more shallow boxes, lined with paper; which place, if possible, in a small room, of the temperature of 64°, and keep it up to that degree for the two first days, by means of a fire in the chimney, or, still better, in a brick, tile, or porcelain stove; or, for want of these, in an iron stove; and use tanners' waste-bark, turf, or charcoal, for fuel, to promote and keep up a regular heat, day and night. The third day increase the heat to 66° the fourth to 68°, the fifth to 71°, the sixth to 73°, the seventh to 75°, the eighth to 77°, the ninth to 80°, the tenth, eleventh, and twelfth, to 82°.* It is impossible to expect regularity in hatching, if reliance be placed upon our very variable weather; and it is the regularity of the worms coming forth, which will ensure their uniform growth, save much trouble in feeding and attending those of various ages, and cause the whole, or the greater part, to form their cocoons at the same time, provided proper care be given during their progress.

* For the importance of a thermometer, see p. 59.

When the eggs assume a whitish hue, the worm is formed: cover the eggs with white paper, (never use a newspaper,) pierced full of holes the size of a large knitting needle; the worms when hatched will creep through them: turn up the edges of the paper to prevent their crawling off. Lay twigs of the mulberry, having two or three dry and young leaves, on the paper, to collect the worms, and more as they continue to mount. For want of mulberry leaves, feed for a short time upon lettuce leaves, perfectly dry; if large, they should be cut in strips, and the mid-rib thrown aside. The worms first hatched are the strongest; nevertheless, if only a few come out on the first day, give them away, to save trouble, and depend upon those which appear on the second and third days. Give away, also, the produce of the fourth day, and then the whole stock will go on regularly. If it be wished to rear all that are hatched, endeavor to keep the produce of each day separate, by numbering the boxes and shelves. When the leaves on the twigs are loaded with worms, the boxes containing them are to be removed to a new apartment, and the worms gently placed on clean stout white paper, laid on frames filled with crossed rattans, (see plate 2, fig. 3,) giving them a plenty of room. The shelves over which these frames should slide, may be four feet square, and fixed to upright posts, (p. 55;) or the apparatus of the Rev. Mr. Swayne may be used to great advantage; (see p. 56, and the description.) They may be multiplied as required. Whether a distinct building or apartment in a dwelling house be devoted to a large parcel, it is absolutely necessary to secure the command of a gentle circulation of air, by having ventilators in the windows,* floors, and doors. (See p. 55.) Red ants are deadly enemies to silkworms. To prevent their attacks, the posts containing fixed shelves ought not to touch the ceiling, nor must the shelves reach the walls; their legs should be smeared with thick molasses; those of Mr. Swayne's moveable frame may also be thus treated, or they may stand in a plate of water. Guard also against cockroaches and mice.

The worms being all hatched, whether they are to remain in the first apartment, or be removed to a distinct building, the heat must be reduced to 75°, for as the worms grow older they require less heat.

When a large quantity of worms are to be removed from the boxes, the task is to be performed in the manner directed in p. 69. The mode of transporting a parcel to a distance, is also given in p. 70.

First Age.

That is, until the worms have passed their first moulting, or changed their first skin.

The apartment must be light, but the sun must not shine on the worms in any stage.

Feed the worms with the most tender leaves, four times a day, allowing six hours between each meal, giving the smallest quantity for

* One or more tin circular ventilators, in place of panes of glass, would always secure a regular circulation in the apartment: they could be stopped when their motion is not required.

the first feeding, and gradually increasing it at each meal between the moultings.

In about an hour and a half, the silkworms devour their portion of leaves, and then remain more or less quiet. Whenever food is given, widen the space for them. Scattered food may be swept into its place.

Experiments may be made, as to the comparative advantage of using chopped or whole young leaves. Dandolo insists upon the necessity of the former. If chopped, a sharp knife must be used, to prevent the leaves from being bruised, and thereby causing the exudation of water from them, which would prove injurious. On the fourth day, the skin becomes of a hazel color, and looks shining; their heads enlarge, and assume a silvery bright appearance. These are marks of their approaching first change. Their food, on this day, therefore, may be diminished, or when these appearances take place, but not before. Enlarge the spaces as the worms increase in size. The leaves ought to be gathered a few hours before they are used, that they may lose their sharpness. They keep very well in a cool cellar three days. The leaves ought to be gathered over night, for the morning's meal, to prevent the danger of collecting them in rainy weather. The leaves must be pulled carefully, and not bruised. On the fourth day, the appetites of the worms begin to decrease, preparatory to their first moulting, and their food must be diminished in proportion as the previous meal has not been completely eaten. If the precarious heat of the weather has been depended on, the first change may not appear until the sixth or seventh day.

In the course of the fifth day, all the worms have been torpid. During this period, they must, on no account, be disturbed. A few begin to revive at the close of it; some leaves may be then given. After the first moulting, the worms are of a dark ash color.

Second Age.

As the worms are fond of the young twigs, some of these should be spread over them with the leaves attached, upon which the worms will immediately fasten, and they may then be removed to a clean paper; or lay a strip of chopped leaves near the worms, and they will leave the old food. The litter is to be taken away; but, as some of the worms often remain among the old leaves, they ought to be examined; to this end, the litter should be removed to another room, spread out on a table, and a few twigs placed over it, on which the worms, if any, will mount, when they may be added to the others. This rule must be attended to after every moulting. The two first meals of the first day, should be less plentiful than the two last, and must consist of the most tender leaves. These must be continued for food until after the third moulting.

If, between the moultings, any worms should appear sick, and cease to eat, they must be removed to another room, where the air is pure, and a little warmer than that they have left, put on clean paper, and some fresh leaves, chopped fine, given to them. They will soon recover, and then may be added to the others.

On the third day, the appetite of many worms will be visibly diminished; and, in the course of it, many will become torpid. The next day, all are torpid: on the fifth, they will all have changed their skins, and will be roused. The thermometer should range between 73° and 75° in the second age.

The color of the worms in the second age, becomes a light gray; the muzzle is white, and the hair is hardly to be seen.

It must never be forgotten, that, during the time the worms are occupied in moulting, the food should be greatly diminished, and no more given than will satisfy those which have not yet become torpid on the first day, or those which have changed their skins before the others.

Third Age.

During this age, the thermometer must range between 71° and 73°. All the worms should be roused before any are removed. The revived worms are easily known by their new aspect. The latest worms should be placed apart, as their next moulting will be a day later also; or they may be put in the hottest part of the room to hasten their growth. This rule must also be observed in the next moulting. Increase the spaces.

The second day, the two first meals are to be the least copious, the two last the greatest, because towards the close of the day, the worms grow very hungry. The third day will require about the same quantity as the preceding last meals; but, on the fourth day, as the appetites of the worms sensibly diminish, not more than half of the former feed will be required. The first meal is to be the largest: feed those which will eat at any time of the day. The fifth day still less will suffice, as the greatest part are moulting. The sixth day they begin to rouse.

Fourth Age.

The thermometer should range between 68° and 71°. If the weather be warm, and the glass rise several degrees higher, open the ventilators, exclude the sun, and make a slight blaze in the chimney, to cause a circulation of the air. Widen the spaces for the worms. The leaves must now be regularly chopped in a straw cutting box, or with the chopping knife. The food is now to be greatly increased on the second, third, and fourth days: on the fifth, less will be required, as, in the course of this day, many become torpid: the first meal, on this day, should therefore be the largest. On the sixth, they will want still less, as nearly all will be occupied in effecting their last change of skin. Renew the air in the apartment by burning straw or shavings in the chimney, and open the ventilators. If the evenings be cool, after a hot day, admit the external air for an hour. None but full grown leaves should be hereafter given to the worms; and they must all be chopped. Avoid the fruit, as they would prove injurious, and add greatly to the litter. On the seventh day, all the worms will have roused, and thus finish their fourth age.

Fifth age, or until the worms prepare to mount.

In a large establishment, the exhalations from the worms and their litter, united to the heat of the atmosphere, sometimes cause great mortality among them; the means of preventing which, are treated under the head of diseases. But if proper cleanliness be observed, and a free circulation of the air permitted, no sickness is to be feared. The thermometer should be about 68°. The constitution of the worms being now formed, they begin to elaborate the silk vessels, and fill them with the silky material, which they decompose and form from the mulberry leaves.

Give abundance of room; do not let the worms lie so close as to touch one another; for their respiration will thereby be impeded; continue to feed regularly and fully, as the appetite of the worms now becomes voracious; rather give food five times a day than four; even six small meals will not be too many. The last meal should be late at night, and the first of the next day, in the morning, at an early hour. The worms are not to be again moved, and the hurdles must be cleaned, as directed in page 94. On the seventh day of the fourth age, they have attained their largest size, viz: three inches long, and begin to grow shining and yellow. The appetites of some diminish; but that of others continues, and must be supplied, to hasten their maturity. The effects of a sudden increase of heat in the weather, at this time, will be highly injurious—see p. 96. For the mode of preparing the cabins for the formation of cocoons, and the treatment of the worms, the gathering of the cocoons; the selection and preservation of those intended for seed; the birth and coupling of the moths; the laying and preservation of the eggs, see p. 97, and following.

With respect to the temperature of the room, in which the cocoons intended to produce moths, are kept, the rule prescribed by Dandolo should be attended to. If it exceed 73°, they should be put in a place in which the thermometer will remain within the limited degrees. Moderate temperatures are, without exception, best adapted to the silkworm, the chrysalis, and the moth. Notwithstanding the difficulty of ascertaining the male from the female cocoon, yet the advantages of separating them are such, that the attempt is recommended by Dandolo to be made. The benefits arising from the separation are, 1st, that, before the moths unite, they would have leisure to evacuate the excrementitious fluid they contain, the retention of which, as will be seen in the chapter on the diseases of silkworms, is injurious to the eggs. 2d, That the moths not united are only handled once. They must now be watched, and after they have evacuated the fluid, they are to be united, and put on a frame covered with linen, which, when full, must be carried into the dark room, to remain during the time they ought to be united.

If, through inattention, a store of leaves has not been provided, and they are collected during rain, they must be thoroughly dried before being given, as they will inevitably sicken the worms, if fed with them when moist. To dry a large parcel, see the chapter on diseases of silkworms.

On early food.

Sow the seeds broad cast of the white, or of the native red mulberry tree, in well prepared ground, as soon as ripe; they will soon vegetate. If the winter be cold, cover the plants with straw, or long manure. The first season, they will afford a small quantity of leaves; but, if watered in dry weather, the leaves will be abundant in the second year. The plants will grow better if the seed be sown in drills, thinned out to proper distances, and kept clean. The leaves of these seedlings are only recommended for the young worms, and as a resource for food until the leaves of the standard mulberry trees have put forth. They have already been proscribed as food for silkworms during their whole course—p. 53.

CHAPTER XIV.

DISEASES OF SILKWORMS.

A careful perusal of the principal practical authors upon the rearing of silkworms, and attention to their progress during the last season, in a large establishment, have led to the conclusion, that the diseases to which silkworms are subject in their various stages, may be referred to the following causes:

1st. Errors in hatching the eggs, and treatment of very young worms.

2d. Bad air of the district in which they were bred.

3d. Impurity in the air in which they are kept, arising from deficient ventilation, from exhalations of the litter of the worms, and of their manure, which has been permitted to accumulate.

4th. Too close crowding, owing to which cause their spiracles or breathing holes, were stopped, and the expiration and inspiration of air prevented.

5th. The quality and quantity of food.

6th. Improper change of food.

7th. Peculiar constitution of the air in certain seasons, against which no precautions can avail.

8th. Frequent changes of temperature in the room in which they are kept.

I. *Diseases from defect in the eggs.*

1st. When the apartment destined for the coming forth, and laying of the eggs of the moth is too cold, (54° or 59°,) the impregnating liquor will not be perfected; and, consequently, does not sufficiently act upon the eggs, to give them the ash color, which, in the course of fifteen or twenty days, indicates the perfect impregnation. The un-

impregnated eggs produce no worms, and those imperfectly impregnated, bear in them the seed of diseases which destroy the silkworm in various stages of its existence.

2d. When the room is too hot, (77° to 81°:) if the male delays coupling, it loses much of the impregnating liquid. If united to the female too soon, upon issuing from the cocoon, she has not time to evacuate a superabundance of excrementitious fluid with which she is loaded. She therefore becomes disordered, and the impregnating liquor of the male is weakened, by admixture with this matter of the female; consequently, the eggs are imperfect.

3d. Dampness prevents the eggs from drying, the embryo becomes affected, and diseases engendered.

4th. When the place, where the eggs were kept, or hatched, has been or is damp, the slow and gentle evaporation of the matter contained in the shell, by which it insensibly attains the state assigned to it by nature, is prevented.

5th. When the eggs are too thickly heaped together, they heat, even at a low temperature, and the embryo becomes injured.

No disease will occur, 1st. if the temperature of the place where the moths are kept, be maintained between 68° and 75°. 2d. When the apartments are dry. 3d. When cloths on which the eggs are deposited, are not folded too much, and are hung on the frames which have been described.

2. *Diseases from mismanagement of good eggs, and treatment of very young worms.*

1. When the embryo just verging to the worm state, in a moderate temperature, is suddenly exposed to a much greater heat, its organs become decomposed, and the shell of the worm will appear more or less red, which is a certain sign of future disease.

2. When, on the point of transformation into the worm, the embryo is suddenly exposed to a lower temperature; the damage is then proportioned to the length of time the heat has acted upon the embryo.

3. When silkworms being just hatched, are exposed to a higher temperature than that in which they come forth, or the contrary, when the worms are exposed to a colder temperature than that in which they come forth.

II. *Diseases from the bad air of the district in which Silkworms are reared.*

Low marshy places, and those in which the air is liable to stagnate, are very liable to produce disease. The combination of heat and moisture is death to them. On the contrary, it is universally agreed, that high and dry places are not only peculiarly favorable to the growth and health of the insects, but that the silk there produced by them, is much preferable to that from worms reared in places less elevated.

III. *Diseases of Silkworms from impurity in the air of the laboratory.*

When the air of the apartment is not renewed, particularly in the fourth and fifth ages, the damp stagnates in it, the transpiration is checked, the dung and litter ferment, and emit noxious exhalations:* the skins of the worms become relaxed, and disease follows in a few hours. The necessity of preserving a free circulation of pure air in the apartment, has been often insisted on, in the preceding pages. The prevalence of a superabundance of damp air, may be known by the use of a hygrometer, or indicator of moisture, and it is easy to remove this, by employing the means suggested for expelling the heavy air, and replacing it by light fresh exterior air.

On the means of purifying the air.

Hitherto it has been reckoned a good method of purifying the air of a laboratory to burn some odoriferous or vegetable substance, to produce a grateful smell, while, instead of purifying or improving the air, by these means, they were rendering it considerably worse. It has been erroneously imagined, that what usually occurs in our perception of offensive effluvia, should be equally applicable to the noxious qualities of the air, which, as they affect the lungs, have great influence on the general system of animal life. The case is however dissimilar; in producing a pleasant smell in the room of which the air is vitiated, we do but disguise to the sense the bad quality of the air we breathe, but the lungs are not less affected. We are then mistaken in employing such means in the laboratory.

In whatever manner any odoriferous vegetable may be burnt in the centre of the room, and not in the grate, and however grateful the odour may be, it will consume a part of the respirable or vital air contained in the room, and consequently must injure the air.†

We should here speak of the harm which may be done by the smoke of chimneys which spreads often through the laboratory, and remains stagnant in it. It is very certain that, if the smoke often infests the apartment, it is to be feared we may see all the silkworms of a laboratory perish in a moment.

Let us now mention the means of purifying the internal air of the laboratory, and of neutralizing and destroying, in some degree, the poison which exhales from the fermented substances on the wicker hurdles, and to produce the drying of those that are inclined to ferment. It must first be observed, that this remedy will not cost above 30 cents for a laboratory of worms proceeding from five ounces of eggs.‡

* It is surprising to find how large a portion of mephitic air disengages, particularly in the fifth age, from the silkworms, in an establishment spacious enough to contain the worms proceeding from an ounce of eggs.

† Mr. Nysten also gives his opinion, as to the total inutility of all perfumes to purify the air of an apartment in which silkworms are kept, p. 105.

‡ The use of the fumigating bottle and the hygrometer, can only be necessary in very large establishments. Pure air, food regularly given, cleanliness, abundance of space, and a proper temperature, are all that the silkworms require, to ensure their health.

Take six ounces of common salt, mix it well with three ounces of powder of black oxyde of manganese; put this mixture in a strong bottle, with two ounces of water, cork it well with a common cork.

Keep this bottle in any part of the laboratory farthest from the stove or fire-places. In a phial put a pound and a half of sulphuric acid, (oil of vitriol,) and keep this phial near the other bottle, with a small cordial glass and an iron spoon; and this is the manner of using it: Put into the small glass, two-thirds of a spoonful of oil of vitriol, pour it into the large bottle, and there will issue a white vapor.

The bottle should be moved about through the laboratory, holding it high up that the vapor may be well spread in the air.

When the vapor ceases, the bottle may be corked, and replaced: even should there be no perceptible difference between the interior and exterior air, during the fifth age of the worms, it is good to repeat this fumigation three or four times a day in the manner just explained. When repeating the fumigation, the quantity of oil of vitriol poured into the large bottle may be diminished. The stated quantity of ingredients will be sufficient for a laboratory of five ounces of eggs. The bottle may be left open an hour or two in the last days of the fifth age of the silkworms; and placed here and there in the laboratory, and even on the corners of the wicker hurdles, to diffuse the vapor thoroughly.

This remedy may be employed, whenever, on going into the laboratory, the air appears to have an unpleasant effluvia, and that there is any closeness, or difficulty of breathing.

1st. It may take place when the litter of the silkworm is removed, particularly in the fifth age.

2d. When in moist weather the air of the laboratory continues damp, even after having made the blaze, which renders the fermentation still quicker.

This fumigation may be of use also towards the end of the fourth age, if the air be perceived to be impure. It may not be needed in all cases, until after the fourth age of the silkworms, and at the beginning of the fifth age.

If there are several small fire-places in the laboratory, and that blazes are frequently made in them to agitate the air, fumigations will not be so much required.

It must be observed that care should be taken not to drop any of the oil of vitriol, either on the skin or clothes, as it burns; and to hold the bottle above the height of the eyes and nose, when it is open, because the vapor is very searching, and would be dangerous and unpleasant. Should the substances in the bottle harden, a little water may be added, and stirred with a small stick. This easy remedy is more powerful than all perfumes commonly used, and produces five advantages in the laboratory.

1st. The vapor in spreading immediately, destroys any unpleasant effluvia.

2d. It diminishes the fermentation of the litter, and dries it up.

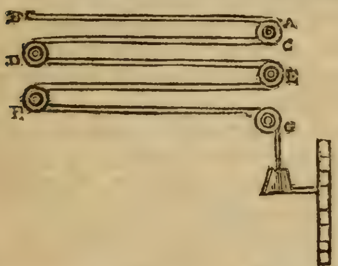
3d. It neutralizes the effect of all the miasmata, and deleterious emanations that might attack the health of the silkworms.

4th. It revives the silkworms, gently stimulating them, because it is composed in a great measure of pure, vital air.

5th. The vapor is not alone favorable to the health of the silkworms, but influences the goodness of the cocoon.*

Of the Hygrometer.

Scientific men have invented various instruments fitted to measure the quantity of moisture which the air may contain in any circumstances, using, in their construction, bodies which attract the dampness from the air easily, and stretch by degrees, and which contract again when the air is dry. A plate of common table salt, coarsely pounded, may answer to show the moisture or dryness of the air. Hygrometers of various materials have been constructed. The annexed cut, will give a good idea of a useful, simple, and cheap one. The principle upon which it is constructed, may be thus briefly illustrated. The effect which a moist atmosphere has on any twisted cord, is that of diminishing its length, by causing the spirals to approach each other. If, therefore, a long piece of string be attached to the peg at B, and conveyed round the pulleys C, D, E, F, G, with a weight suspended beneath, we may, by referring to the index hand and scale, readily ascertain the amount of moisture that has been absorbed by the vegetable fibre. If the string be soaked in a solution of common salt in water, it will more readily indicate any slight accession of humidity in the atmosphere.†



It would be desirable to have two hygrometers in a large laboratory, placed within a certain distance of each other, to ascertain the various degrees of moisture in different parts of the laboratory.

* So much importance is attached to the use of the acid fumigations by Dandolo, and others, that it has been thought right to retain his directions respecting them: but it is proper to remark, that Mr. Nysten, after a course of laborious experiments with them, and with other fumigations, comes to the decided conclusion, that they are totally inefficacious as means of curing the actual diseases of silkworms. He even found, in an experiment with two thousand sick worms, that more died in a room where the fumigations were continually used, than in another, in which the pure air was allowed to circulate freely among a similar number. He allows, however, that the fumigations may act as a preventive remedy, by neutralizing the bad air of the apartment. It is with this view that Dandolo uses it. He confirms the repeated positions of Dandolo, and the experience of all practical writers and cultivators, that to prevent the diseases of silkworms, it is only necessary to hatch the eggs in a regularly increased heat, to feed the worms with good and dry leaves, to keep them in a pure air of the temperature prescribed above, and, finally, to observe rigid cleanliness. He remarks that, it was not Paroletti who first used acid fumigations for worms, but Rigaud de Lille, who says that he thereby diminished the mortality among them; but candidly acknowledges, that he freely admitted the external air at the same time.—Nysten sur la Maladies des Vers a Soie, pp. 101, 103.

† T. Williams. The Scientific Gazette, part 2d, p. 81. London, 1825

When the hygrometer indicates a very damp state of the atmosphere, wood shavings or straw should be burnt in the fire-places, to absorb the humidity, and replace it by the external air which is dried by this same blaze. Blaze is preferable to mere fire, for two reasons: the first is, that, for instance, with two pounds of shavings, or of dry straw, there can be attracted, from all points, towards the chimney, a large body of air, which issues at the flue of the chimney. While, in the meantime, this air is replaced by another quantity of exterior air, which spreads over the wicker hurdles, and revives the exhausted silkworms. This change of air may take place without effecting any material variation in the degree of heat in the laboratory. If, on the contrary, thick wood were employed, it would require more time to move the interior air; ten times more fuel might be consumed, and the laboratory would be too much heated. The motion of air, all circumstances being equal, is in proportion to the quantity of blaze of the substances that burn quickly. When wood shavings or dry straw cannot be procured, small sticks of dry and light wood may answer. As soon as the flame rises, the hygrometer shows that the air has become drier, and the degrees of it can be seen distinctly.

The second motive which should lead us to prefer the blaze, is the light it diffuses. It cannot well be imagined how beneficial this light is, which penetrates every where, nor how much it influences the health and growth of the silkworms.

IV. *Diseases from want of room.*

When silkworms lie so thick on the wickers, or feeding frames, that they cannot feed with ease, a difference in their development will result, and large healthy worms will be found mixed with small and sickly worms. This mixture affects the periods of their transition; some will be lively, some torpid, and others still requiring food previously to their transition: this confusion kills great numbers, or causes them to drag on a sickly existence.

Silkworms, as stated in their anatomical description, do not breathe by the mouth, but by small apertures, which are placed near their legs, and called stigmata, or spiracles. These breathing holes are almost all stopped when the worms are heaped together; hence their breathing becomes difficult, their transpiration ceases, and sickness takes place.*

V. *Diseases from the quality or quantity of food.*

Remarks and cautions on this head, will be found in the course of instructions for rearing the silkworm; but it is proper to notice the mode in which the food affects them.

* Several thousand worms were killed in one case last summer, from the above cause, near Philadelphia. See the account of the disease called tripes.

1. The preservation of the health of silkworms, depends essentially on the leaves being perfectly dry when given to them. Wet leaves invariably produce a diarrhœa.

In the four first ages, the leaves may be easily kept two or three days; but on the days when the silkworms are voracious, a number of persons must be continually at work to provide for their daily consumption, and dry the leaves a day or two before they are wanted.

To dry in a day several hundred pounds weight of mulberry leaves, proceed in the following manner:

When the wet leaves are brought in, have them spread on brick floors, or on earthen floors, which should be as clean as possible. Then, according to the quantity, one or two persons must spread them with wooden forks, turn them, throw them about, and move them much. This, often repeated, very soon shakes off the wet. If the floor is not of bricks, and the ground becomes wet, the leaves should be raked off to another and drier part of the floor.

Although the leaf appears quite dry after this operation, it still contains a great deal of water in its folds, and even on its surface.

Then twenty or thirty pounds of leaves should be spread upon a large coarse sheet, and doubling it into the shape of a large sack, two persons should hold the four corners, and shake the leaves well about from one end of the sheet to the other, until they appear to be quite dry, which will be the case in a few minutes.

Should it be required further to dry the leaves, by burning a large heap of shavings, and some faggot sticks, and placing the leaves nearly all round the fire, taking care to turn them well with clean pitch-forks, they will become, by these means, as dry as if they were gathered at noon on a fine day; it may be effected, as is required, in either way. Should the leaves be only wet with dew, drying them with the sheet will be sufficient.

2. The experienced Pullein says, that the leaves of mulberry trees which grow in moist grounds, or in places shaded from the sun, and those from suckers produced from the trunk, roots, or principal arms, being full of sap and moisture, crude and immature, will produce fatal distempers in silkworms: even by giving them only one feeding, they are surfeited, and throw out of their mouths a greenish liquor, and a clear humor out of the pores of their skins, and out of the little point growing near the tail. This clammy moisture, by rubbing against one another, closes up the spiracles, or breathing holes.

3. Young worms should invariably be fed upon young and tender leaves. The strong nourishment derived from full grown leaves, as has been already mentioned, produces disease in them. Old leaves must be reserved for worms in their advanced ages.

4. Over feeding and scantiness of food, are the remote causes of disease. Unceasing attention should therefore be paid, to have the worms regularly supplied with food, and in proportion to their appetites.

VI. *Diseases from change of food.*

When silkworms have been fed upon the leaves of the native red mulberry tree, they sometimes become diseased, when these leaves

are changed for those of the white species: and the same effect takes place when the order is reversed. In the first case, if permitted, they will eat so ravenously, as to be deprived of the ability to digest their food, and will burst; in the latter, a derangement of their functions, and general debility takes place. From the facts detailed in page 44, of the leaves of both species of the mulberry being indiscriminately eaten, when mixed, and given to the worms, it might be supposed that no injury would arise from a change of the leaves of the white to those of the red species, but the following case, among others which could be cited, shows that the experiment is not safe. "On one occasion, a neighbor being deficient in white mulberry leaves, about the time the worms were preparing to spin, gave them a quantity of the black [red] mulberry leaves. The worms fed readily upon them, but immediately sickened, and performed their task of winding very imperfectly."* It is possible, that, in this case, a partial cause of the effect produced, may have been the quantity of the food given to the worms. The change of nourishment, when rendered necessary, should be gradual. The danger arises, as in the preceding case, from a substitution of one leaf for another, in the late stage of their existence: for it has been already observed, that, before this time, silkworms can be supported upon lettuce and other leaves, and that afterwards resort can be had safely and beneficially to those of the mulberry. A recent experiment shows that, until this critical epoch no injury will attend a change of the foreign for the native leaf. Mr. Prince, of Flushing, Long Island, "fed some silkworms until they were half-grown, upon the white mulberry, and then finished them upon the native species; they grew so rapidly, that they commenced spinning in twenty-one days, and produced excellent silk."

VII. *Diseases from peculiar constitution of the air.*

The injurious influence of certain states of the air upon the production of fruits, has long been observed by farmers and horticulturists, particularly in respect to grapes; and the same influence is often experienced by the cultivators of silkworms. Dandolo has noticed the extremely unfavorable state of the atmosphere in Italy in the year 1814. These peculiar states of the atmosphere in certain localities, not being referrible to its sensible qualities, renders it impossible to guard against the injurious effects produced by them on silkworms.†

When such a state of the atmosphere takes place, we must be the more particular and attentive in guarding against the usual and known causes of disease.

* George A. Tuffts, Esq. of Worcester county, Massachusetts: answer to the silk-circular.

† It is much to be regretted that science has not yet enabled us to ascertain the precise causes to which the bad air, in particular places, is to be ascribed. The Eudiometer will give the constituent proportions of the air of a place; but repeated experiments with it, on land and sea, in balloons, and steeples highly elevated, and in deep caves, in an orchard in bloom, and in the chamber where a malignant fever prevails, give results so very nearly similar, that it is impossible to ascribe the health of one place, or the prevalence of an epidemic in another, to the greater or less abundance of any portion of the airs which enter into the composition of the atmosphere.

VIII. *Diseases from sudden changes of temperature.*

The great importance of preserving silkworms uniformly in that particular degree of heat which ample experience has proved to be most proper for each particular stage of their short existence, has been fully pointed out in the course of the instructions for rearing them; and as no cause will more certainly produce disease, than inattention to this point, it is proper to notice it in this place. To ensure regular growth to the worms, and the gradual evolution of their fine organs, it is essential to protect them against sudden changes of temperature, which often amount to 40°, in the United States, in the course of twenty-four hours. Hence it is absolutely necessary to regulate the heat of the apartment by a thermometer, and to warm it by means of a stove of brick, tile, or porcelain, in preference to one of iron; because the heat communicated by any of the three first, will be much longer uniform, than when one of the last is used. The tender nature of the insect causes it to be extremely sensible to a diminution of temperature, and when this takes place, to the extent of several degrees, they become chilled and torpid, they cease to eat, the digestion of their food is interrupted, their growth is checked, and the foundation of disease is laid.

Again, danger to their health will arise from an incautious increase of heat, after being thus chilled; and exposure to sudden and great heat, when near the time of spinning, will cause silkworms to cease eating, to become enfeebled and relaxed, and sometimes to die. The Abbe Sauvage* particularly notices the danger to their health from this cause. In the summer of 1825, vast numbers were killed from it, in Mansfield, Connecticut.†

PARTICULAR DISEASES OF SILKWORMS.

The Passis.—This disease appears after the first moulting, where the worms advance unequally in growth; they are observed to be short, thin, and without vigor or appetite: it is ascribed to their being too much heated in their early state. The remedies consist in separating them from the healthy worms, putting them in another apartment which is well ventilated, giving them tender leaves, and in preserving them in a uniform temperature, which ought to be a little higher than that in which the healthy ones are kept; for although heat, unduly applied, was one cause of their disease, yet, when feeble, they require more warmth than healthy worms to restore their vigor.

The Grasserie.—This appears towards the second moulting, and in the third or fourth ages. It is ascribed to the food being too substantial or nourishing for the young worms. They eat, but they do not digest their food: hence they swell, their bodies become opaque and of a green color, and their skins tear from the least touch, and some-

* 3d Memoir, p. 70.
† John Fitch, Esq.

times spontaneously from over distension. Their bodies are also covered with a viscous oily humor, which transudes the skin. Mr. Nysten says, that it is owing to the too glutinous nature of the food given to the worm in the second and third ages; because he has seen the disease attack worms when thus fed, which those that had eaten tender leaves escaped; and from the prevalence of the disease in Piedmont, and in the Department of the Mouths of the Rhone, where the Spanish mulberry, which has hard and large leaves, is cultivated, whilst it is seldom seen in the Department of the Drome and Isere, where that variety of the mulberry is rare. If this theory be correct, (and it certainly is very rational,) the remedy is obvious: to feed the worms in their three first ages with tender leaves, and to avoid the variety of mulberry mentioned: this, by the way, it is thought, has not been introduced into the United States.

The Lusette.—About the fifth age, silkworms are sometimes attacked with a disease called *lusette*, or *clairette*, from the shining appearance of their bodies. Their heads also increase in size; they cease growing, and die without forming cocoons. On opening them, their stomachs are found full of a glairy transparent fluid, without any remains of food; and hence it has been justly ascribed to a neglect of the supply of mulberry leaves. This theory was proved by Mr. Nysten, who produced the disease by starving some worms for twenty-four hours. The means of prevention and of cure are therefore obvious. Care should, however, be taken to separate the affected worms from the healthy ones, and to supply them with food in a gradual manner, to prevent an opposite disease arising from too sudden repletion.*

The Yellows.—This disease appears toward the end of the fifth age, when the worms are filled with the silky fluid, and are about to spin. The Abbe Sauvage ascribes it to exposure of the worms to sudden and great heat. It consists in a yellowness and swelling of the body, an enlargement of the rings, an appearance of the feet being drawn up from the puffiness of the surrounding parts. The worms also cease to eat, and run about, leaving stains of a yellow fluid, which exudes from their bodies. The yellowness first appears round the spiracles, or breathing holes, and gradually diffuses. It is a kind of anasarca or dropsy of the skin, arising from the infiltration of the nutritive fluid through every part of their bodies. The insects soon become soft, and burst. The acrid humor issuing from them, will kill any worms that touch it. Sauvage also ascribes it to a defect of transpiration, to indigestible food, and to exposure to cold during rainy weather; and directs to dry the air of the apartment, by lighting fires in the chimney of the apartment during rainy weather. The yellows or jaunesse, and the grasserie, are deemed the same disease by Sauvage and Nysten; but the grasserie is more serious when it occurs during the moulting, than when it takes place towards the last age. In the former, it is a general disease; in the latter, it is merely accidental. Whenever

* Recherches sur la Maladies des Vers a Soie, par P. H. Nysten, p. 116. Des Vers a Soie, par M. Reynaud, p. 111, Paris, 1824.

they do occur, they are to be dreaded, and should be attended to without delay. The diseased worms must be removed to a separate apartment, where a change of air, aided by fires, may cure them. The dead worms should be carefully buried, to prevent their being eaten by poultry. In one case of this disease, which occurred in Bucks county, Pennsylvania, in the year 1772, oak leaves were laid in the way of the worms, and were greedily devoured by them, and cured. In another, these leaves were given by design, and with similar good effect. The particular species of oak was unfortunately not mentioned.

The Muscardine.—This is caused by a continuance of a hot, dry, close, or calm state of the air; and shows itself by black spots in different parts of the worm. These spots afterwards become yellow, and finally red, or of the color of cinnamon, which is diffused over the whole body. The worm becomes hard and dry, and is covered with a white mould. The disease appears in the fifth age. The remedy is, to purify the air, by the use of the fumigations recommended by Dandolo, and by the admission of fresh air from the external atmosphere, and to cause it to circulate by means of ventilating openings in the room.

The Tripes, or Mort Blanc.—This disease appears during moist or rainy weather. Mr. Nysten proved by experiments,* that it also proceeds from the confined exhalations of the worms and their litter. They become flaccid and soft, and, when dead, preserve the semblance of life and health; but they soon turn black, and become putrid. The remedies are obvious: In the first case, the air of the apartment should be warmed, and made to circulate, by lighting fires in the chimney; and, in the latter, by removing the diseased worms to a clean shelf or table in another room. The means of preventing the disease are, uninterrupted circulation of warm dry air, and rigid attention to cleanliness.

The foregoing account of the diseases of silkworms ought not to alarm the cultivator. They will be preserved in perfect health, if the causes mentioned are avoided; or the prescribed means, if used in time, will cure them.

CHAPTER XV.

PREPARATIONS FOR REELING THE SILK.

How to take off the flos, or loose silk, from the cocoons: the reasons for sorting them.

Before the cocoons are reeled, it is necessary to free them from that loose, fuzzy silk which is on their outside, and is called flos; it being of so fine and loose a consistence, and partly broken by taking it from the branches, or frames, where the worms had spun them, that it can-

*Sur les Maladies des Vers a Soie, p. 40.

not be reeled off. It may be taken off by opening it on one of the ends of the cocoons, and then thrusting out the hard part of them, clearing off, at the same time, the loose silk adhering close to them, and mixing this part with the flos, to make ordinary cheap silk. Then sort the cocoons according to their different degrees of hardness. If the strong, the tender, and the double ones are mixed, the trouble is not only greatly increased, but, in reeling, the threads frequently break, and the value of the silk is thereby lessened. For the proof of this, let us suppose only two cocoons, one compact and hard, and the other of a loose and soft substance, thrown together into the hot water, in order to be reeled off together, and to make one thread. If, now, the water be sufficiently hot to let the hardest of the two cocoons wind off with ease, by dissolving its gumminess, then that water will be too hot for the other, the substance of which is loose, so that it will run off in burrs; that is, flakes of the silk will come off without being drawn to their extent; which burrs, as they pass the guide-wires, will endanger the breaking of the thread, filling it also with lumps and inequalities. On the other hand, if the water be of the proper temperature for the soft cocoon, so as not to occasion the above inconvenience, it will then not be hot enough for the hard cocoon, so that its thread will not be given off, without some stretch and violence, which endangers its breaking, and giving the trouble of adding a fresh cocoon; and, in both cases, the single fibres of the cocoons being unequally stretched in reeling, will make the combined thread the weaker, and less even and glossy; since the single fibre of that cocoon which was most stretched by the reel, will, upon disbanding, contract itself more than the other, and be separated from it in some places. On these accounts, having first separated the double cocoons, and also those which contain nothing but flos, with any others, which, being imperfectly formed, cannot be reeled, sort the perfect cocoons into three kinds, according to their different degrees of hardness, which can be readily perceived, and throw them into three different baskets.*

The cocoons may be divided into two general heads, or classes; the white and the yellow. In the yellow, we meet with all the shades from a bright yellow, diminishing, at last, to white; some few are a pale green. We may reckon nine different qualities of cocoons, which are met with, more or less, in all filatures or reeling establishments.

1. The good cocoons are those which are brought to perfection, and are strong, hard, of a fine grain, and little or not at all spotted.

2. The pointed cocoons are those, of which one of the extremities rises up in a point. After having afforded a little silk, the point which is the weakest part, breaks, or tears, and it is impossible to continue to wind them any longer; because, when the thread comes round to the hole, it is, of consequence, broken, and the whole contains nothing but ends.

3. The cocalons are a little larger than the others; yet they do not contain more silk, because their texture is not so strong.

* Pullein on the culture of silk, p. 251.

4. The dupion, or double cocoons, are so called, because they contain two, and sometimes three worms. They interlace their threads, and make the silk called dupion.

5. The soufflons are imperfect cocoons, the contexture of which is loose, sometimes to that degree that they are transparent, and bear the same proportion to a good cocoon, as a gauze to a satin. These cannot be wound.

6. The perforated cocoons are so called, because they have a hole at one end; for which reason they also cannot be wound.

7. The calcined cocoons are those in which the worm, after the formation of the cocoon, is attacked with a sickness, which sometimes petrifies it, and, at other times, reduces it to a fine white powder, without in the least damaging the silk. On the contrary, these cocoons produce more silk than the others, because the worm is lighter. They are to be distinguished by the noise the petrified worm makes when the cocoon is shaken. In Piedmont, they sell for as much more as the others. It is very rare to see a parcel of 25 lb. of them at a time: 6 lb. 3 oz. of these cocoons have produced 1 lb. fine silk, of five and six cocoons.

8. The good choquette, consists of those cocoons in which the worm dies before it is brought to perfection: they are to be known by the worms sticking to one side of the cocoon, which is easily to be perceived, when, on shaking it, the chrysalis is not heard to rattle. These cocoons are of as fine silk as the others, but they are to be wound separately, because they are subject to furze out, and the silk has not so bright a color, nor is it strong and nervous.

9. The bad choquette is composed of defective cocoons, spotted or rotten; many of these cocoons may be wound together; they make very foul, bad silk, of a blackish color.

To judge whether a cocoon be good, observe if it be firm and sound; if it has a fine grain, and the two ends round and strong, and capable of resisting pressure between the thumb and finger. The cocoons of a bright yellow yield more silk than the others, because they have more gum; but this accounts to the winder only, because all the gum is lost in dying. Pale cocoons have less gum, lose less in winding, and take a better white or pale blue.*

To the foregoing kinds of cocoons, another is mentioned in recent French works, and called sattiny. Its tissue is coarse and like flannel, and the surface shines. The silk of this cocoon is bad.

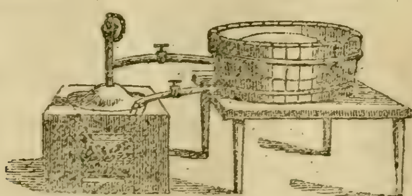
As it will be useful to know the precise dimensions of a stove and basin used for heating water for cocoons, the following details are given by Mr. Stephenson, of an establishment at Montauban, in France: Height of the stove from the ground, twenty-two inches; length of the stove, twenty-nine inches and a half; breadth, twenty-four inches; height of the iron bars for supporting the charcoal from the ground, for holding the fire, twelve inches; width of the door, or opening at the bottom of the stove for taking out the ashes, and for

* Trans. Amer. Philos. Soc. vol .

giving air to the fire, nine inches; width of the door to put in the charcoal, seven inches and a half; length of the oval copper basin built on the top of the stove to hold hot water, twenty inches and three quarters; width of the basin, sixteen and a half inches; depth of basin, three inches and three quarters; breadth of the rim of the basin, one inch and a quarter.

Instead of using a common stove or furnace to heat water for the cocoons, steam has been proposed and used by Messrs. Gensoul and Aldini. Upon the plan of the first, the steam is admitted directly into the water containing cocoons intended to be reeled; but the last adopts another mode, which, upon a large scale, is certainly to be preferred. A copper boiler covered, and with a hollow bottom, has a vertical tube adapted to the centre of the cover, with a cock, by means of which, the water intended to furnish steam is admitted. This boiler will hold four pints,* (French) and at the beginning of the process, it is to be filled to nearly two-thirds. The vertical cylinder has a tube with a cock, through which the steam is introduced into a wooden tube, placed on its side, to the external surface of a vase above it, and gives out steam at its extremity through a series of small holes turned towards the bottom of the vase; the holes are to avoid the inconvenience arising from the too rapid escape of the steam. This vase is of copper, and contains six pints of water. The steam-box is tinned on the bottom inside, and a little inclined to the side of the boiler, with which it communicates by a tube, with a cock, conveying back the condensed steam to the bottom of the boiler. Thus the water in which the cocoons are put, is regularly and permanently heated, without any loss of water, supplying the steam, and without the injurious ebullition of the water which takes place when steam is introduced directly into it, and which causes the rapid and irregular motion of the cocoons in the basin.†

The annexed cut will give an accurate idea of the construction of the apparatus of Aldini:



Upon a small scale, the common clay furnaces made in Philadelphia, answer very well to heat water in a copper basin placed upon them.

The temperature of the water is to be regulated, 1st, by the nature of the silk, resulting, in part, from the quality of the food upon which the silk-caterpillars have been fed. This is exemplified in a striking

* A French pint is about a quart American measure.

† Recherches sur l'application exterieure de la Vapeur pour e'chauffer l'eau dans la filature de la soie: par le Chevalier Aldini. Paris, 1819.

manner by a fact recorded by Aldini,* which is, that, in Piedmont and in Lombardy, the gummy cement of the cocoons is so easily soluble, as to require the water to be heated only to 60° or 66° of Reaumur, (168°, 181° of Fahrenheit,) while the cocoons spun in the south of Italy, and particularly in the Papal territories, require a heat of 80° of R., (212° of F.) owing to the greater tenacity and solidity of the gum. 2d, The state of the cocoon, as regards its firmness, influences the heat of the water, as shall presently be mentioned. Experiments can alone, therefore, determine the various degrees of heat requisite for the water in different places, and for the several varieties of cocoons, and even for different parcels of cocoons of the same sort. As this is a point connected with the success of the operation, it affords another argument for the use of the thermometer, in order to ensure it, and to prevent the delay and trouble which will ever ensue from guessing at the heat of the water, by dipping the finger in it. Our own sensations are very inaccurate tests of the heat of the water; the use of the thermometer, besides saving much time and trouble to the spinner, will ensure an evenness of thread, and perfection to the whole operation.†

The perforation of the cocoons by the moths, destroys the continuity of the thread, and thus spoils them for reeling. They must, therefore, be either reeled off, before the moths come forth, or after the worms have been killed: the means of doing this, are, by exposing them to the steam of boiling water, or to the heat of an oven. But as it is a fact, well established, that cocoons reel more readily, and that the silk is of a superior quality, when obtained without their having been subjected to either of these expedients, every exertion should be made to reel them as soon as proper, after the cocoons have been formed.‡ When the business is conducted upon a large scale, it may be impossible to do this; in which case, the moths may be prevented from coming forth at their usual time, by placing the cocoons in a cold vault, cellar, or ice-house, as formerly mentioned on the authority of the Abbe Sauvage.§

Practical men are divided as to the best mode of killing the chrysalis: some preferring that by steam, and others that by the heat of an oven.—Both methods shall be described.

The academy of Nismes deemed it so important to ascertain the best mode of killing the chrysalis, as to institute a set of experiments on the subject, in the year 1809: and they came to the conclusion, that the steam of hot water effected the object best, without injuring the quality of the silk. Six ounces of white cocoons were submitted

*Recherches, &c. &c. p. 23.

† A mercurial thermometer, as already said, chap. 6, should be preferred, for those made with spirit of wine are seldom accurate.

‡ It is the general practice, in Connecticut, to reel off the silk, as soon as possible after the cocoons have been formed, and without killing the insect by either of the means mentioned.

§ See chap. 1, at the close.—If placed in an ice-house, the box containing them must be well covered to prevent the absorption of moisture.

to a temperature of 75°* of steam in a close vessel, furnished with a safety valve for half an hour,† when the cocoons were taken out, and the chrysalides were found dead. The texture and color of the cocoons were uninjured, but their weight was reduced from six ounces to five ounces three grains. ‡

The following description of a furnace for steaming cocoons in France, is given by Mr. Stevenson:

"It is built of brick, the ground part holds the fuel, which is placed upon a grate; over that, and at a little distance, a copper cauldron is fixed to contain the water; above this is another grate, upon which the cocoons are placed in a basket, the twigs of which are wide apart, the more readily to admit the steam. To this grate and cauldron, access is had by a door opening above the entrance of the fire. The furnace is arched with bricks, that, when the door is shut, the steam may be retained within; which, in the space of eight minutes, is found effectually to kill the insects in the cocoons. The basket is then taken out and put aside, to let the cocoons dry; another basket is then placed in the furnace with more cocoons, taking care to keep up the fire so as to have the water in the cauldron always boiling."

If the furnace be arched, a safety valve should be fixed on the top; a wooden cover would be safer, over which a woollen rug may be thrown. The foundation ought to extend beyond the body of the brick work, and an opening in it left to admit air to the fuel, and to take out the ashes. It should be provided with a sheet iron door with hinges, having a smaller door in it, after the manner of the door of a close stove; over this opening a fire stone, or cast iron plate, must be placed, to support the brick work above, and to prevent it from being injured when the wood is put in. A vacancy of two inches must be left between the boiler and the surrounding brick work, to cause the flame to pass round it, before the smoke is permitted to escape. Fuel will thus be saved, and the regularity of the heat be more certainly kept up, which is an essential point to ensure the death of all the chrysalides. That no doubt may remain on this head, the cocoons should be covered instantly, after being taken out of the furnace, with a woollen cloth, one or two hours to confine the heat. They must then be dried without delay, or the silk will be injured. Exposure to the air in dry weather will effect this; in damp weather, they may be put in an oven, gently heated, on clean cloths of linen or muslin, or in baskets.

* The French writer from whom this account is taken, does not mention the thermometer used on this occasion. It was either that of Celsius, called the Centigrade, or of Reaumur, both of which are used in France. The scale of Celsius, between the freezing and boiling points, is divided into 100°. The freezing point is marked 0, the boiling point 100° 75° of this, then, would be equal to 60° of Reaumur, or 167° of Fahrenheit. In Reaumur's scale, the space between the boiling and freezing points is divided into 80°. The freezing point is marked 0, the boiling point 80°; on this scale 75° is equal to 202° of Fahrenheit, or 94° of Celsius. It is probable the writer refers to Reaumur's scale.

† This length of time is quite unnecessary, and even injurious to the cocoons.

‡ Traite complet de mechanique, par Borgnis, tom. 7, p. 15. Paris, 1820

To bake Cocoons.

In five or six days after the cocoons have been detached from the branches or frames, carefully pick out all the spotted cocoons, and put the rest in long flat baskets, filling them within an inch of the top; cover them with paper, and a wrapper over it; put these baskets in an oven, the heat of which must be as near as possible to that of one from which the bread is just drawn, after being baked.* After the cocoons have remained an hour therein, draw them out, and to ascertain if the worms be dead, take out from the middle of the baskets a dupion, and open it; if the worm be dead, it may be concluded all the rest are so, because the contexture of the dupion being stronger than that of the other cocoons, it is consequently less easily penetrated by the heat; it ought to be taken from the middle of the basket, because, in that part the heat is the least perceptible. After the baskets have been drawn out of the oven, cover them with a thick woollen rug, leaving the wrapper as it was; and pile the baskets on one another. If the baking has succeeded, the woollen cloth will be covered with large drops of water, the thickness of the little finger. The baskets may stand covered thus for five or six hours, in order to keep in the heat, which stifles those worms which have resisted the heat of the oven. It is a favorable sign when some of the butterflies appear alive among the baked cocoons, because it is certain the others are not burnt; and in the attempt to kill the last worm, many cocoons might be burnt, as they would be exposed to more heat than that particular worm. If there be some strong and some weak cocoons, and there has not been time to wind them while they are fresh, (that is, without baking,) give the preference to the weak cocoons for winding, and bake the strong ones; because the latter, containing more gum, support the baking better, and suffer less than the weak ones. If the cocoons are bought, put them into baskets, and set them in the sunshine, (if any,) in case the oven be full, in order to stun the worms, and prevent them from injuring the cocoon during that time; place them also for an hour or two, in the open air, before they are put into the oven; because, when they are brought in and heaped on each other, they become heated and soft, and the exposure to the air restores their firmness. When the cocoons are thoroughly baked, spread them in thin layers on shelves, distributed into as many stories as the chamber will admit, two or three feet apart, above one another, and turn them every day; for, if this be neglected, they would become mouldy, and moths would destroy them. It is necessary to pick out the spotted cocoons and the bad choquettes, which would communicate their infection to all the rest that may be near them; these should be wound as soon as possible, to prevent them growing worse.

* The heat should be a few degrees under that of boiling water, or 212° of Fahrenheit; 80° of Reaumur. The oven should not be hot enough to scorch a sheet of paper.

Of royal, perforated Cocoons and Soufflons.

The royal cocoons are those kept for eggs. The worm having made a hole for his passage, the silk is cut, the continuity of the fibre interrupted, and cannot be wound, and is in the class of the perforated cocoons. Neither can the soufflons be wound, because their silk, being the produce of a weak, sick worm, has not the necessary gum; besides, it cannot be wound, because the fibres are interlaid and entangled. These cocoons may, however, be profitably employed for carding and spinning, when subjected to particular treatment, which shall be hereafter described. To calculate the value of these sorts of cocoons, the following calculations may be observed, viz:

If the good cocoons are worth - - -	100
The perforated are worth - - -	33⅓
The soufflons do. - - -	25
The royal cocoons do. - - -	250

But if the royal cocoons are not picked out of the best for eggs, they are worth only 200. The best fleurett is made of royal cocoons; next in value is that of perforated; and the worst, of soufflons.*

Mode of reeling silk from the best Cocoons.

Preliminary Remarks.—The reeling must be performed in dry weather, and when the air is perfectly calm. If done in a building or shed, it should be open on one side, to enjoy sun and air, and walled on the other, to screen off the wind, which would blow about the fibres and threads.

The softest water must be chosen for soaking the cocoons. The proper temperature for it cannot be ascertained until the reeling is commenced, owing to the different composition of the silk. Some cocoons will require water heated from 168° to 190°; others from 190° to 202°. Some point between these extremes may be chosen to which the water should be heated in a first experiment. One thing is certain, that, in the United States, it must never reach the boiling point, or 212°.

The good cocoons, the white and yellow, are the easiest to wind. The sattiny and the cocalons require water less heated than the others. If hot water be used for the last, they furze out in winding. The dupions, the choquettes, the steamed cocoons, and those which have been kept a long time after being baked, require the hottest water. The dupions require to be soaked five or six minutes before they can be reeled. The cocoons in which the chrysalides have not been killed, by either steaming or baking, give out their silk very easily, and in water less heated than the last mentioned sorts. The temperature of the water most proper for each particular species of cocoon being ascertained by the thermometer, it must be kept to that degree by dir-

* Trans. Amer. Phil. Soc. vol. 2.

ping the instrument in it frequently; and the fire under the basin must be lessened or increased as occasion may require. A little attention will soon enable the person who has the management of the basin, to preserve the water at the proper degree of heat.

The reeling is effected by the use of the apparatus represented in plate 1, fig. 1.* The person charged with the management of the cocoons in the basin, must be provided with a small whisk of broom-corn, or of birch twigs cut sharp at the points, and, being seated behind the basin previously filled with soft hot water, and the basin placed upon a furnace containing burning charcoal, she must throw into the water a handful or two of cocoons of one sort and degree of firmness, and press them gently under the water for two or three minutes, in order to soften the gum of the silk, and thereby to loosen the ends of the filaments. She is then to stir the cocoons with the end of the whisk, as lightly as possible,† until one of the fibres, or filaments, adheres to it, when, disengaging it, and laying aside the whisk, she is to draw the filament towards her, until it comes off quite clean from flos, or coarse silk, which always surrounds the cocoon, and the fine silk begins to appear: then, breaking off the thread, and collecting the flos first taken off, she must put it aside. The whisk is then to be applied again, to get hold of the fine fibres, all of which must be set apart, each fibre by itself, by fixing it to a piece of wood kept near to the furnace for that purpose, or to a frame of wood placed all around, and on the edge of the copper, till the whole, or the greatest part, are arranged in this manner, which are thus in readiness to be thrown in, to form the thread of silk to be wound off. This done, she is to unite a number of the fibres, according to the fineness of the intended‡ thread, and delivers the compound thread to the reeler, who puts it through one of the holes in the iron plate, placed horizontally above the basin containing the cocoons and water. Another thread is, in like manner, to be prepared, and passed through the adjoining hole. This process is repeated with the two other holes at the other end of the plate; the two threads are then crossed twenty or twenty-five times, and the ends of each thread passed through the guide-hooks, (rampins,§) MM, of the traversing bar I, and on the contrary side to the hole in the iron plate through which it had previously been passed. They are then to be

* There are several kinds or patterns of reels. The one here referred to, was imported by the writer from Genoa into Philadelphia, in the year 1826, and answers perfectly. Mr. D. Tees, No. 150, North Front street, and B. F. Pomeroy, corner of Walnut and Dock streets, Philadelphia, are recommended to those who wish to have silk reels made.

† The cocoons should be just touched. If they be struck roughly, the fibres of the silk, in place of coming off singly, cling together in lumps, which prevents it from winding off.

‡ For fine silk, four fibres, from four cocoons, are to be passed through each of two holes in the iron plate, most distant from each other. The rule for inferior cocoons will be hereafter mentioned. Two skeins of silk, from good cocoons, are always reeled at the same time, whether the silk be fine or coarse. See plate 1, fig. 1.

§ If these were made of brass wire, the threads would more readily pass through them, and not be so liable to rust, as when iron wire is used.

carried forward, and made fast to one of the arms of the reel N. The points of attachment of the two threads will be regulated by the distance between the rampins.* Both threads being fastened to the reel, it is to be turned with a regular, even motion, at first slowly, until the threads are found to run freely and easily: for it will happen that some of the ends, which were taken to compose the thread, were false, because, in taking off the flos, there may be two or three breaches made in the beginning of the fibres, which, in winding, will soon end, and must be added anew to make up the number designed for the thread. It might, therefore, be proper, in the beginning of the thread, to put a few more cocoons than it is intended to continue, which will soon be reduced to the proper number.

The crossing of the threads is so essential to their perfection, that it must not, on any account, be omitted. It is necessary to promote the dissipation of the moisture imbibed by the fibres, and thus prevents the injurious glueing of the threads upon the reel. The friction of the threads also removes the knots, inequalities, and roughness on them, and causes a perfect adhesion of their fibres, and hence ensures their strength, their uniform thickness, and cylindrical form, which otherwise would be flat.† Figure 1, in plate 1, will give a perfect idea of this first step in the preparation of silk. It represents two threads formed from 16 cocoons.

As soon as the pods begin to give the thread freely, the reel is turned with a quicker motion. If the pods leap up often, and beat against the iron plate P, the motion of the reel must be slackened; and if the threads come off in burrs, it must be turned quicker. Of this the spinner, who has her eye upon the balls and thread, must, as she sees occasion, apprize the reeler, and, at the same time, the fire must be increased or diminished, that the reel may be allowed a proper motion, which ought to be as quick as possible, without endangering the breaking of the thread, or hurrying the spinner, so that she cannot add fresh cocoons as fast as the old ones are ended.

The quicker the motion of the wheel is, the better the silk winds off, and the better the end joins to the thread. One might imagine that the rapidity of the motion would overstrain and break the thread; but, from constant experience, it has been found that the thread never once breaks from the rapidity of the motion, but, on the contrary, that the quicker the motion is, the more advantageous it is for winding the silk.

* The person having the management of the cocoons in the basin, should have very smooth fingers, as the most trifling roughness of the skin will cause great embarrassment. If the skin of the fingers, therefore, of the person mentioned, be rough, it must be rendered smooth, by being rubbed with sand-paper, or dog-fish skin.

† Nouvelle Encyclopædie Methodique, art. Soierie, p. 21. From this work it appears that the number of these crossings is prescribed by the 4th section of the law in Piedmont, of long standing, for the regulation of the reeling of silk, to be 18 or 20 times at least. For coarser silk, the number of crossings is to be increased. The various processes of the manufacture of silk in Piedmont, are regulated by law, (the result of long experience as to the best mode of procedure,) and are enforced by a strict inspection of public officers, in order to preserve the character which the raw silk and stuffs of that country has long enjoyed.

While the reel is turning, the spinner must continually add fresh fibres to each thread as fast as she can find the ends, not waiting till some of the number she began with are ended, because the internal fibres are much thinner than those constituting the external layers; but must constantly prepare fresh ends, by dipping the whisk among fresh cocoons, of which such a quantity must be occasionally thrown into the basin, as will suffice to supply the two threads which are reeling, but not more; because, by being too long soaked in the hot water, they would wind off in burrs. The cocoons thrown in, must be often forced under the water, that they may be equally soaked: for, as they swim with their greater part above water, that part would remain hard and stubborn, while the part which is under water would be too much soaked; or some hot water may be thrown upon them frequently with a brush, and also on the cocoons which are reeling, when they grow dry at top, and yield the fibres with difficulty. The supplying fresh ends, when the cocoons are exhausted, or diminish, or the fibres break, is performed by taking one end of a fibre, and throwing it lightly on the one that is winding, and rolling them between the thumb and the finger, or gently pressing them.

As often, therefore, as the cocoons are partially wound, are exhausted, or the fibre breaks, fresh ones must be joined, to keep up the number requisite, or the proportion: thus three new ones may be wound, and two half wound, or four new ones, and the silk will then be from four to five cocoons. The adroitness in adding fresh threads can only be acquired by practice. The difficulty of keeping the thread even is so great, owing to the increased fineness of the fibre inside, that, (excepting a thread of two cocoons,) we do not say a silk of three, of four, or of six cocoons, but a silk of three and four, of four and five, and of six to seven. In coarser silk, we do not calculate so nicely, as one cocoon more or less: we say, for example, from twelve to fifteen, from fifteen to twenty cocoons. In beginning a thread of ten cocoons, from sixteen to twenty will sometimes be required to preserve a uniform thread, after a portion of the first layer has been wound off.

The quantity of silk which can be reeled in any given time, is in proportion to the quickness with which the spinner can add fresh cocoons. Thus, if we suppose that every cocoon, at a medium, will either break or be wound off at the end of five hundred feet, then, if five such pods are reeled together, a fresh end will be wanted at every hundred feet that are reeled; if ten are reeled together, one will be wanted at every fifty feet; if sixteen together, then at thirty-one feet, and so on. The seldomer that cocoons end or break, the greater number of them can one spinner attend, which shows the advantage of sound cocoons, of an expert manager, and of every artifice, which can hinder either the breaking of the single fibres, or of the whole thread.

When, in the progress of reeling off a set of cocoons, the fibre is observed to diminish in size, in place of supplying additional fibres from more numerous cocoons than were at first in play, in order to keep up

the uniformity in the size of the thread, the following practice is adopted in the Cevennes, a famous silk district of France.*

"In preparing fine silk, the cocoons are not wound off entirely, so as to leave the pellicle of the chrysalis bare, for two reasons: first, because the additional fibres required to be added, when the first and strong part of the fibre is observed to be spent, might make the compound thread too stout, and would thus cause a waste of silk; secondly, because the fibre of a cocoon, which has been entirely wound off, besides being weak, also abounds in knots, which would cause it to break in winding, and injure its uniformity, in which the goodness of the thread mainly consists. Therefore, in winding fine silk, when the cocoon has given off three-fourths and a half of silk,† it must be replaced by another cocoon; the remainder of the first cocoons are to be set aside, and their silk added to that of an inferior quality. When the first parcel of cocoons is nearly finished, take out, with a ladle, all those on which some silk has been left; let them be opened, the chrysalides taken out, and the shells put in a basket, with the coarse fibres first pulled off with the hands from the cocoons, which were ordered to be laid aside. These cocoons, which are partly wound off, must on no account be permitted to remain in the basin: for they will obscure and thicken the water, and injure the color and lustre of the silk, which can then be used only for dark colors: besides this, the consistence of the silk is injured, and waste ensues in the winding."‡ The shells are to be buried, to prevent them from becoming offensive; or they may be added to the manure heap. As a general rule, the water must be changed when it is discolored.

When the spent cocoons leap up, and adhere to the iron plate, they must be immediately taken away, else, by choking the passage, they will endanger the breaking of the thread.

When the reel has remained any time idle, the thread between the basin and the wires or rampins, must be wet, to cause the thread to run easily. Keep also the teeth of the wheels, and the mortises, in which the traversing bar plays, wet, to ensure regularity and ease in their movements. In winding the good cocoons, some defective ones will be found among them, which will not wind off, or are full of knobs; these must be taken out of the copper, and kept by themselves; they are called bassinats, and are to be wound apart as coarse as possible; they make a foul silk.

The breaking of the fibres is principally owing either to bad cocoons, viz: being ill formed, (as they will be when the worms were disturbed and interrupted during their spinning,) or the fibres may break by an

*This appears to be a preferable mode, as regards ease of performance, and the preservation of a uniformity in the thread, to the old plan of increasing the number of fibres from fresh cocoons, to add to others which may be nearly spent.

† Reynaud says, p. 237, that a cocoon will preserve a uniform fibre for 300 feet. A French foot is equal to 13 American inches.

‡ De Vers a Soie et de leur Education, selon la pratique des Cevennes: par M. Reynaud, p. 234, Paris, 1824.

In Italy, the pellicle or shell is used to make artificial flowers, which are said to surpass those from any other material. Essai sur Histoire, &c. par Delongchamps, p. 73.

improper regulation of the heat in the water: first, when it is not sufficient to make them wind off easy; or, second, when it is too great, and occasions burrs, which may stop at some of the holes through which the thread runs. Cocoons, also, which have two worms enclosed, will perpetually break. The whole thread may also break, by burrs stopping at the holes in the plate, or by the reel's being turned by jerks. It may be fastened, like the fibres, by laying the parts on one another, and giving them a little twist. To avoid the breaking, occasioned by burrs, the rampins should be just so wide as to let them easily pass.

It would be convenient for the spinner to have a little stick erected close to the side of the basin, to hang her whisk on, and also a sharp fork, with which she may draw away the spent cocoons; or such, as being near spent, stick at the holes in the plate: and as the whisk will frequently take up more ends than are immediately to be added, and as the spinner will sometimes have occasion to employ both her hands, the brush will, at that time, conveniently hang by the basin, while the cocoons, which are attached to it, remain in the water, and the ends will be in readiness as they are wanted. When cocoons rise to the iron plate, they are to be drawn down between the fingers of the spread hand.

If the spinner be under the necessity of leaving off work for any length of time, the cocoons should all be raised with a skimming dish out of the water, till her return; otherwise, by oversoaking, they would wind off in burrs; but it is best to continue the reeling without interruption, and to let fresh, but equally experienced persons succeed those who are tired.

The person who turns the reel, should have an eye to the threads, and to the guide-wires (rampins) through which they pass, that he may apprize the spinner when any thing is wrong: for her eyes will be sufficiently employed about the cocoons. The reeler might also rectify any thing discovered to be amiss in those parts of the thread which are near the reel: for one hand will always be unemployed, and a stop must occasionally take place.

Though the reeler can change hands, as they tire, by turning, yet, for ease, he might have a support for his arm opposite to the axle of the reel, and so turn the handle only by that motion which can be given to it by the arm moving upon the elbow as a centre.

As the heat of the water in the basin will require to be varied, according to the ease or difficulty with which the different sorts of cocoons give off their silk, the spinner should always have some cold water within reach, in order to cool that in the basin quickly, when the silk comes off too easily, and in burrs. The water is also necessary for the woman managing the cocoons, to cool her fingers, and to sprinkle the iron bar when it becomes heated. Some chips or shavings should also be at hand, to increase the heat quickly, when the cocoons do not yield their silk readily.

If there should happen to be any sand in the water, the heat causes it to rise to the surface and fix on the cocoons—the thread of which will break as if cut; for this reason, the utmost care must be taken to

guard against it, and to remove it. Previously to being boiled, the water should be permitted to settle, and the pan must be carefully wiped; if necessary, the basin should be covered while the water is heating. If sand be perceived in the water, it must be poured off, and the sand washed out, for a single grain may cause the fibre to break.

When the cocoons are first put in the water, if the silk rises thick upon the brush, or comes in lumps, it is a sign that the water is too hot; if the thread cannot be caught, the water is too cold. When the cocoons are in play, if they rise often to the holes in the iron plate, the water is too hot; if the cocoons do not follow the threads, it is too cold.

Keep an equal number of cocoons working at each end of the basin, in order to preserve the thread of silk of an equal size. When there are fewer on one side than the other, the silk becomes smaller at that side, and the thread will break. Therefore, throw in the cocoons one by one, and never more than two at a time.

It will be seen, by observing the position of the thread upon the reel, that the different layers do not lie parallel to, nor upon, but cross one another. This is owing to the mechanism of the apparatus, and is particularly contrived to effect this object, which is essential to the perfection of the process, and one to which the acknowledged superiority of the Italian silk is to be ascribed. It is effected by the see-saw or horizontal motion of the traversing bar, and is produced by the different number of the teeth in the pinion of the axle, and in the wheels at the ends of the shaft E, and in the pinions on the top of the post K, which catch and work upon one another. Without this crossing, the threads, from their gummy nature, would inevitably adhere, and render the subsequent windings and twistings of the silk very difficult; causing the threads frequently to break, and, when joined, to form knots, which, in weaving, cannot pass through the reeds, and hence injure the beauty of the stuffs. But the mechanism mentioned of the traversing bar, prevents the threads lying over each other upon the reel, until after it has made many revolutions. Borgnis* says, that a thread cannot be found to occupy the same place it had at the commencement of the reeling, until after eight hundred and seventy-five turns of the reel. During this time, the exposure of the threads to the air, causes the first layer to dry completely, and hence no adhesion between them can take place. The double irregularity of movement which takes place between the traversing bar, and the axle which moves it, forms also an internal motion, the effect of which is to imitate, in the unravelling of the cocoon, the same method employed by the silk caterpillar in forming it: for it is a fact, as before said, that the silk fibres of the cocoon are spun on it in zig-zags, like those formed by the silk reel, and, consequently, the operation of the reel is an imitation of nature, of which the industry of the caterpillar, instructed by her, is the prototype.

With the view of increasing the facility of drying the threads, the law of Piedmont requires the distance between the posts or supports

* Traite de Mechanique, applique aux Arts, vol. 7.

of the axle and the traversing bar, to be "two aliprand feet," or three feet four inches and two-fifths, American measure.*

Seven rotations of the reel, cause the traversing bar to move five times from side to side.

Dandolo says, it is a well known fact, that, of two reelers, each reeling 7½ pounds of cocoons of the same quality, one will obtain only six ounces and a half, or perhaps still less, while another will turn off eight ounces

Mr. Nouaille says, that "a woman at Novi, (Italy) experienced in the business, with the assistance of a girl to turn the reel and attend the fire under the caldron, can, with ease, reel off one pound of silk, consisting of four or five cocoons, of the most perfect quality, in a day.†

When a desired quantity of silk has been wound on the reel, pick off all the loose silk; then take a little handful of the coarse silk, and, after washing and squeezing it, dip it in cold water, and rub over the silk on the reel, stroking up also the silk with the palm of the hand: then turn the wheel with all possible velocity, with open windows, if the reeling has been done in a room, for about eight or ten minutes, to dry the silk effectually; which done, take off the reel, put it in a dry, airy place, but not in the sun. This is done to clean the silk and give it a gloss.‡

When one reel is taken off, another should be put on, that the work may not be delayed. Every winding apparatus must have two reels.

In preparing the dupions for winding off, more are put into the basin at once than of the finest kind. They must be first well cleaned from the flos on their outsides. The water also must be boiling hot; and, as the silk they yield is of a coarser quality than the other, and has a good deal of flos upon it, the person who turns the reel must take the opportunity, while the one who manages the basin is preparing the cocoons for winding, to clean and pick off the loose silk from that which is on the reel. The dupions intended for ordinary sewing silk, are to be wound from 15 to 20 cocoons. The rest may be wound as coarse as possible, that is, from 40 to 50 cocoons. These serve to cover and fill up coarse stuffs, and are likewise used for sewing silk. The good choquettes are to be wound according to the uses they are intended to be put to, but not finer than from seven to eight. The bad choquette may be wound from 15 to 20. The sattiny cocoons, so called from their resemblance to satin, require water only moderately hot. The proper heat will be found by observing the manner in which the silk comes off from the first of them which are put into the basin; and, as already said of cocoons generally, if it come off thick, cold water must

* This regulation constitutes the 6th article of the Piedmont law of April 8, 1724, on the silk manufacture. The distance between the axle of the reel and the traversing bar, in the apparatus imported into Philadelphia, in 1826, by the writer, is four feet eight inches.

† Trans. Soc. Arts, Lond. vol. 6, p. 177.

‡ This is the practice in France, according to Mr. Stevenson; but the 18th article of the law of Piedmont, for the regulation of the silk filature, expressly forbids the smoothing to be done in any way except with the dry hand.—Nouvelle Ency. Methodique, article Soie.

be added, until the proper temperature be attained. They must not be allowed to remain long in the water, and there should be only a few of these cocoons put in at a time. The water for the dupions and choquettes must be changed four times a day.

Of disbanding the silk from the reel, and tying it in skeins: preparation of the silk for use.

One cannot consider attentively the manner in which the silk is reeled from the cocoons, without observing that the single fibres of which the thread is composed are liable to suffer very different degrees of stretching as they are wound from the cocoons. If the cocoons are not well sorted, this different degree of extension will be the greater; and, even when they are sorted, they must still be subject to the same, because some are a little longer in the water than others, and therefore give their silk easier; and also the weak latter ends of some cocoons wind off with the strong first part of others.

The fibres being thus stretched unequally, will occasion (when the skein is taken from the reel too suddenly) those fibres which are most stretched, to contract more than the others, by which their union will be in some measure destroyed, and the thread composed of them rendered less compact and firm, the fibres appearing in several places disjoined from one another. To remedy this, the skein should remain there six or eight hours, until the unequal extension which it suffered in winding, is, by the stretch which it undergoes on the reel, brought nearer to an equality; and, until the thread, by being well dried, has its fibres firmly united.

When the skein is finished, there should be a mark tied to the end of the thread, otherwise it may be difficult to find it, if it mixes with the threads of the skein.

When the skein is quite dry, proceed to disband it from the reel. First, squeeze it together all round, to loosen it upon the bars; then, with a thread made of the refuse silk, tie it on that place where it bore on the bars of the reel; then slide it off the reel, and make another tie on the part opposite to the one first made; after which, double it, and tie it near each extremity, and then lay it by for use or sale, in a dry place.

After the silk has been taken from the reel, it undergoes the following operations, to prepare it for putting in the loom:

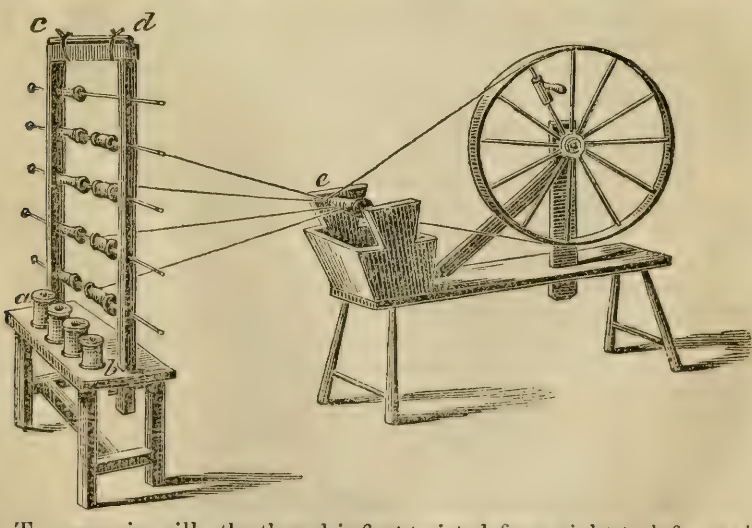
1st. It is wound from the skein upon bobbins, in a winding machine, (plate 3, fig. 1.) 2d. It is twisted on a mill, in the single thread—the twist being in the direction of from right to left, and very light. 3d. Two or more threads, thus twisted, are doubled, or drawn together through the fingers of a woman, who, at the same time, clears them, by taking out the slubs which may have been left in the silk by the negligence of the reeler. 4th. It is then thrown, or organzined; that is, two or more threads are twisted together, either slack or hard, as the intended manufacture may require; but the twist is in an opposite direction to the first twist, and it is wound at the same time in skeins

upon a reel. 5th. The skeins are sorted according to their qualities, and then dyed.

Before the silk is wound upon the bobbins, it must be prepared by breaking the gum at the four corners of the skein, which lay upon the reel when wound off from the cocoons: this is done by rubbing the silk in those places between the fingers, until the threads are entirely separated. It must then be opened and spread out upon the wheel, and all the straggling ends cut short, and the gouts cleared away.

The twisting of the compound thread is intended to unite the constituent fibres more firmly than they can be by the gum alone. This is effected by the tramming machine, and the thread is called tram. It is used for the filling of stuffs, and for other purposes, and is, more or less, twisted according to the objects for which it is intended. The whole process, as at present commonly performed, is described in the preamble to Mr. Shenton's account of his improved tramming machine, to be given hereafter. His own apparatus will probably take the place of those hitherto in use.

The annexed cut gives a view of an apparatus* to double and twist silk thread, which will be found very useful for domestic work. The operation of it is apparent from its construction. In place of working it with the bobbins placed between the two upright posts, they may be fixed upon their basis, as seen at *a b*. In this case the threads are conducted over a glass rod, on the top of the frame *c d*, and, from that to the spool *e*, placed above the box before the wheel. The axis of the wheel is not parallel to that of the spool; hence, the band passing over the wheel makes an acute angle with the axis of the spool. This arrangement secures the point of the spindle in a hole which receives it.



To organzine silk, the thread is first twisted from right to left, as already said. The silk, in twisting, turns off on other bobbins, some-

* From the Nouvelle Encyclopædie Methodique, article Soierie.

what larger than the first. These bobbins are then to be exposed to the steam of water, to which have been added two ounces of white, or still better, Castile soap two ounces, eighteen ounces of olive oil, and four or five pounds of wood ashes. The bobbins are to be put in a kettle, the bottom of which is pierced, and placed over the vessel of water, when it boils, with a cloth over it, and permitted to remain until the silk begins to swell and to detach from the bobbins. They are then to be taken away, and the second throw or twist given to the threads, from left to right. The combination of these two throws is called the *pearl*, as the organzine looks like a string of small pearls or beads. It is easy to know if the second throw be perfect, by untwisting part of the organzine, and when it is open, on slackening the hand a little, each thread twists round itself in obedience to the first throw or twist. The water may be filled up as it wastes, but the ashes, soap, and oil, are to be renewed every day.

The warping machine is described in Rees' Cyclopædia, article Silk. The figure is in the 4th volume of plates of that work.

The operation of organzining is described at large, in the explanation of the plate of the throwing machine.

It is probable that Fanshaw's new invention, a sketch of which the writer has fortunately obtained from a very recent publication, will supersede much of the old complicated and expensive silk machinery.*

Preparation of the waste silk.

All the cocoons which have been pierced by the moths, those formed with holes at one or both ends, the light cocoons deemed improper for winding, after the insects have been cut out, or threshed out, and the pellicles remaining after winding off the silk, are to be collected; and if it be wished to retain the yellow color, they are put in a copper kettle with water, and tramped with the feet, turning the cocoons, and adding a little fresh water from time to time, until it be found that the silk separates properly, upon tedding it out with the fingers. They are then tied up in a clean cloth, which is dipped in a clear stream, or water is poured on them, until it runs off without color, and spread out to dry in the sun. Waste silk, intended to remain white, is to be treated in the following manner:

Put the cocoons in a kettle of cold water, and let them lie twenty-four hours: then boil them in a copper kettle, adding a quarter of a pound of soap† for every pound of cocoons: when the soap is dissolved, tie up the cocoons in a clean cloth, put it in a kettle, and boil until the cocoons have become white. The water should entirely cover the cloth; then take out the cloth, and dip it in a clear stream, or pour water on it till it comes off clear; then spread out the cocoons in the sun to dry. Mr. Stephenson, from whose paper these directions are taken, says the merchants prefer the silk cleaned by means of cold

* See the explanation of the plates.

† The quality of the soap is of great consequence: brown soap must not be used.

water, to that which is boiled; alleging that the first loses less of its natural gum, and takes all manner of dies better than that which has been boiled. Before being spun, it is beaten with a rod upon a table, according to Reynaud. A hatter's bow would probably open and separate the fibres more effectually. Would it not then easily form into rolls by being passed through a cotton carding machine?

On spinning inferior qualities of silk.

In every filature, one or more reels are devoted to the spinning with the carrelet,* the inferior qualities of silk which cannot be spun on the common reel. The frame of the carrelet is longer than the silk reel, and has commonly a wheel with four arms; but a wheel with eight will do equal service, if two of them are moveable. The most essential difference in the frames is that of the head pieces. To these are adapted a board which carries two or four bobbins. If there are only two, they are placed longitudinally, one above the other. If two threads are to be wound at a time, two other bobbins are added, and placed between the other two, in the same position. After the cocoons have been thrashed, a number of the fibres are collected to form a thread, which is passed through one of the two eyes of the board of the bobbins, of the same form as that of the traversing bar of the silk reel; then it is wound round both bobbins at the same time: being first carried to the first and returning round the second, it passes between them, giving a twist to the part of the fibre which was extended from one bobbin to the other. This is the only twisting which these threads receive. The spinner then takes the same end and passes it through the eye of the traversing bar, and, attaching it to the wheel, it is set in motion. If it be wished to wind two skeins at one time, a second thread is prepared, and attached to the second pair of cylinders or bobbins, whence it is passed through the second eye of the traversing bar, and then fixed to the wheel at a proper distance from the first end. The silk has little uniformity, is of an obscure hue, and causes much waste in winding. It is used for black stuffs of an inferior quality.

Many manufacturers spin all their good silk, and that of an inferior quality, upon the carrelet, to make the thread called tram. This is slightly twisted, and is used for the filling of stuffs, and for inferior silks for bonnets. One pound of cocoons is required to make one pound of this silk. This thread wastes in winding, but as it is slightly twisted, it parts with its gum more readily in boiling, and takes a finer color than other threads. The dupions or double cocoons, are also reeled on the carrelet. They require to be immersed five or six minutes in hot water, to soften their firm texture. They are used to make sewing silk.

* This apparatus is not mentioned in the French Encyclopædia, nor in Borgni's recent work expressly devoted to the machines used in the arts. The most diligent inquiry failed in obtaining an account or draught of it. The notice given above of its use, is from the work before quoted by M. Reynaud. Any American would render a service to his country by importing the carrelet.

The coarse fibres, which are first taken off from the cocoons, (as directed in the passage on reeling,) and laid aside, are called in France, the *fantasie.* Two pounds of cocoons commonly yield about four ounces and a half of this material, and sells in France for about a dollar and a quarter for two pounds. It is first boiled to deprive it of gum, then carded and spun. The best of it is used for the filling, after being slightly twisted, and the inferior quality for the chain of stuffs. In Connecticut the coarse threads of the cocoons are made into a ball, then reeled, boiled in soap and water, rinsed, dried, cut into one and a half inch pieces, then carded on cotton cards, and spun like wool or cotton.

The thread called in France filoselle, is made in part from pointed cocoons, formed by feeble worms, or in cold seasons; the ends are slightly covered with silk, and, not being entirely close, the water enters and precipitates them to the bottom. More or less are met with in every parcel. They are first deprived of their gum, by being immersed in plain water, or in soap and water, when the filoselle is wished to be white, as before directed. When dried, this filoselle is spun upon the distaff in France, and practice enables the women to form an even and fine thread.

The filoselle thread, made from the tow of the seed cocoons, is esteemed of the first quality, giving no waste. It is spun upon the distaff, in France, but may be spun on the wheel. It is prepared as above directed, and is used to make stockings. The bourre, or waste, is the produce of the remains of the various manipulations which silk undergoes when manufacturing, as reeling, doubling, and milling. It is carded and spun upon the distaff, and sometimes on a wheel.*

In France, the perforated and inferior cocoons, and the waste, are all mixed, and prepared by an apparatus called a devil, to make sewing silk. No description or draught of this could be obtained. The best threads of cocoons are reserved for silk fabrics. In Connecticut, family sewing silk is made from the good cocoons, from which the moths have escaped. The shrivelled case of the pupa, and any eggs which may have been deposited in the cocoon, are first taken out; they are then boiled in soap and water, rinsed, gently squeezed, dried, and spun on a foot wheel. Knitting thread for stockings and mits, is also made from them. They make the best sewing silk, by doubling the thread, reeled from good cocoons, and twisting it on the common wool-wheel. The skein is first boiled in soap and water, and it lies in a dish containing enough soapsuds to keep it moist, while the process of twisting is going on.

The following communication on this subject, was made by Daniel Bulkeley, Esq. of Hampton, Connecticut, at the request of the Secretary of the Treasury:

"The raw silk is first spooled on bobbins, the number of which is in proportion to the size of the intended thread from the first spinning; and, to facilitate the operation, they are put into warm water. The

* Reynaud, p. 251, 265.

silk is again spooled, taking two or three bobbins, according to the size of the intended thread. After being spun, it is reeled into skeins, each of forty yards in length, or half a knot of the country reel, as required by a law of the State. About twenty-five of these skeins are put together, like a skein of cotton or woollen yarn. They are then boiled, adding a small quantity of soft soap, or ley of wood ashes, to cleanse them from the gum. They are then ready for dying.

"Silk twist is spun in the same manner, except that it is always of three cords. The winding of twist is done on a machine imported from England.

"We have a small establishment for spinning by water, with a machine similar to a throstle frame of a cotton mill. The silk is first spooled by hand, on bobbins, which are placed on the top of the frame; the thread of raw silk passing from it under a wire, through a trough of water, then through rollers to the spindle. A single frame may contain from thirty to fifty spindles, and can be attended to by one person. The doubling and twisting may be done on the same frame, at the same time, by giving the bands to a part of the spindles a contrary direction. As many threads are put to a spindle as are required to make a thread of two or three cords. Silk spun in this way is far superior to that done by hand. The machine will spin from two to three pounds in a day. A pound of silk, after being spun and cleansed, will weigh about ten ounces, and form one hundred and seventy skeins; the threads of sufficient size to sew woollens. If spun finer, it will make more. It increases little or nothing in weight when died. Silk is sold by the skein; one hundred of which will measure one-third more than half a pound of Italian or English silk of the same sized threads. One woman can make from twelve to fifteen pounds of raw silk, in a season of six weeks."

EXPLANATION OF THE PLATES.

Plate 1—Figure 1.

Silk Reel of Piedmont.—The frame is 6 feet 5 inches long, $4\frac{1}{2}$ by 3 inches thick. Distance of the upright posts A B, 4 feet $4\frac{1}{2}$ inches.

C C. Length of the braces of the frame, 20 inches in the clear.

D D. Legs of the frame, 2 feet $3\frac{1}{2}$ inches long. E, shaft with a crown wheel at each end. The wheel F, 9 inches and $\frac{1}{10}$ in circumference, has 22 teeth. The wheel G, 10 inches and $2\frac{1}{10}$ in circumference, has 25 teeth. This shaft has an iron pin at each end, 1 inch long. The pin at the end G, plays in a hole in a shoulder near the top of the post O, so as to enable the teeth of the wheel to catch and work in those of the pinion at the end of the axle of the reel, which axle, by means of a pin at the end, also plays in a hole in the post O. The pin at the other end of the shaft, plays in a hole of the post K, and the teeth of the wheel F work in the pinion H, fixed on the top of the post K, by means of a burr screwed on the pin projecting from the post.

and passing through the centre of the pinion. This pinion has 35 feet. On the top of the pinion H, is a crank, having a sweep of 4 inches, and receives, on its top, the end of the iron wire-carrier of the traversing bar I. The crank is fixed half an inch from the commencement of the grooves of the pinion. This crank is shown in the figure H. I, a traversing bar, 2 feet 10 inches long, $\frac{5}{8}$ of an inch wide, $\frac{3}{4}$ of an inch thick, playing through the posts B K: height of the post, from the frame, 17 inches.

L. An iron carrier of wire, No. 1, 18 inches long, fixed to the bar I, to work free by a screw. The other end is fixed by a burr, to the pin passing through the centre of the pinion H.

M M. Two wire hooks or eyes, (rampins,) 7 inches and $\frac{3}{4}$ apart, at equal distances from the ends of the traversing bar, through which they pass. The wires to the commencement of the turns of the hooks, are 5 inches in length.

N. The reel; arms, 2 feet 2 inches and $\frac{1}{10}$ long in the clear; $1\frac{1}{2}$ inches wide, and $\frac{8}{10}$ of an inch thick: rails 20 inches $\frac{3}{4}$ long, 2 inches broad, $\frac{8}{10}$ of an inch thick; two of the arms are jointed, to allow the skeins of silk to be taken off, when reeled and quite dry. There ought to be an extra reel to put in the place of the one taken off, to prevent the work stopping.

O. Upright support for the axle of the reel, on the ends of which the pinion is fixed, to work with the wheel G, at the end of the shaft E. The pinion of the axle has 22 teeth. P. An iron plate with four holes, 12 inches long, slightly hollowed, projecting $3\frac{1}{2}$ inches from the bar: the outside holes are 3 inches from the ends; from the centre of one hole to that of the next, $\frac{3}{4}$ of an inch. Distance from the two inside and nearest holes, 4 inches and $\frac{2}{10}$.

Q. The copper basin to contain hot water, in which the cocoons are immersed, when reeling off. It is 18 inches long, 1 foot broad, and $4\frac{1}{2}$ inches deep.

R. The furnace to contain charcoal, to keep the water hot.

Distance from the centre of the posts A B, and O K, 36 inches and a half. Circumference of the reel 6 feet 11 inches.

Distance from the top of one arm, where it enters the rail, to another arm, $18\frac{1}{2}$ inches.

From the axle of the reel and the traversing bar I, four feet eight inches.

Figure 2 shows the arrangement of the frames for rearing the silk worms, in Dandolo's laboratory.

Figure 3. A semicircular chopper with two blades.

Figure 4. Pierced box to place the moths in. See p. 109, 110.

Figure 5. Frame or tressel to be covered with a cloth, on which the moths are to lay their eggs.

Figure 6. Rope frame to place the cloths on, containing the eggs to preserve them until the spring.

Figure 7. Hook to remove the silkworms, when necessary.

Plate 2d—Figure 1 and 2.

Indigo Cradle.—The end of the upright lever is attached to a cross bar, the ends of which play in a bearing fixed on each side of the cradle, and secured by screws.

From near the ends of the bar, a claw extends to, and embraces, the journals, or arbors, at each end of the middle roller, lying on the bottom of the cradle; the ends of the claws are divided for this purpose, and permit the journals to play in them.

The roller is 12 inches long, and 4½ diameter. There are two other rollers, each a little longer, lying loose, and moved by the one fixed to the claw. The whole is of cast iron.

Mr. Johnson, at the Foundry, Broad-street, Philadelphia, casts these indigo cradles. Twenty pounds of indigo are put in water, in the cradle, over night, and then ground, either by hand or other power, until the indigo is reduced to the state of thick cream, and perfectly smooth.

Plate 2d—Figure 3 and 4.

A frame filled with split rattans, used by Messrs. Terhoeven, of Philadelphia county, to feed silkworms on.

The ends of the rattans are put through holes in the frames, and fastened by wooden pins, in the manner of rattan chair-bottoms. The rattans are crossed by iron wires, and woven in by fine wire, rolled round small pieces of wooden rod.

Fig. 4. A frame used by Messrs. Terhoeven, in preference to bushes, for the worms to form their cocoons in. It is made of four slips of wood, half an inch thick, and as long as the feeding frames are broad. Their ends are pointed, and pass through two pieces of wood, half an inch thick, four inches high, and three broad. Under the whole length of the frame is a thin strip of board, nailed to the end pieces. When one of these frames is filled with cocoons, it must be removed, and an empty one put in its place.

Plate 2d—Figure 5.

Sholl's improved Silk Loom.—A A, the sills. B B, the breast rolls. C, the cut tree. D D, theuprights. E, the burdown. F, the batton. G, the reeds. H, harness. I, the breast rolls. K, the cheese. L, the gibbet. M, treadles. N, tumblers. O, short counter meshes. P, long counter meshes. Q, the porry. R R, cane roll posts. S, cane rolls. T, the weight bar and weight. N N, counter weights. W, the breaking rod. X X, cross rods.

The several advantages of this loom are stated by Mr. Sholl to consist in the following particulars: 1st. It is not liable to unsquare, and yet is more easily moved than the old loom. 2d. It admits more light than the common looms to the workman. 3d. As the cane roll posts are fixed to the floor by screws, the porry may be made of any length,

by only screwing the cane roll posts nearer, or further from, the breast roll. 4. The gibbet is formed in the loom, and therefore the trouble of fixing it is prevented. 5. The bridge of the battons are not nailed to the block, but iron pins are put in the block, and partly go through the bridge, fastened with glue, so that the silk cannot be injured as formerly. 6. The battons rise as the work rises, and keep more true than in the old looms. *Trans. Soc. Arts, London, for* 1790.

Plate 3d.—Figure 1.

Winding Reel.—To wind the silk off from the skeins, in which it is imported or made up, upon wooden bobbins.

The reel figured, is calculated to wind six threads at once, but, by increasing the length, it may be made to receive any number.

Each of the skeins is extended upon a slight reel A A, called a swift: it is composed of four small rods fixed in an axis, and small bands of string are stretched between the arms to receive the skein; but, at the same time, the bands admit of sliding to a greater or less distance from the centre, so as to increase the effective diameter of the reel according to the size of the skein; because the skeins which come from different countries, vary in size, being generally an exact yard, or other similar measure of the country where the silks are produced.

The swifts are supported upon iron pivots, upon which they turn freely when the silk is drawn off from them; but, in order to cause the thread to draw with a gentle force, a looped piece of string or wire is hung upon the axis withinside the reel, and a small leaden weight *e* being attached to it, will cause a sufficient friction.

B B are the bobbins which draw off the threads; they are received in the frame, and are turned by means of a wheel beneath each; the bobbin having a small roller upon the end of it, which bears by its weight upon the circumference of the wheel, and the bobbin is thereby put in motion to draw off the silk from the twist.

D is the layer, a small light rod of wood, which has a wire eye fixed into it, opposite to each bobbin, so as to conduct the thread upon; and, as the layer moves constantly backwards and forwards, the thread is regularly spread upon the length of the bobbin. The motion of the layer is produced by a crank fixed upon the end of a cross spindle, E, which is turned by means of a pair of bevelled wheels from the end of the horizontal axle upon which the wheels for turning all the bobbins are fixed. These winding machines are usually situated in the top building of a silk mill, (when water or steam power are used,) the frame being made of great length, and also double, to contain a row of bobbins and swifts at the back as well as in front. The winding machines require the constant attention of children to mend the ends or threads which are broken, or, when they are exhausted, to replace them by putting new skeins upon the swifts. When the bobbins are filled, they are taken away, by only lifting them out of their frame, and fresh ones are put in their places.

Plate 3d—Figure 2.

A throwsting machine* intended to be worked by hand. B is the handle. It is fixed on the spindle R, which carries a wheel D, to give motion to a pinion upon the upper end of a vertical axle E; this, at the lower end, has a drum or wheel F, to receive an endless strap or band *a a*, which encompasses the oval frame G, and gives motion to all the spindles at once.

The spindles *b b* are placed perpendicularly in the frame G H; their points resting in small holes, in pieces of glass which are let into the oval plank G, and the spindles are, also, received in collars affixed to an oval frame H, which is supported from the plank G by blocks of wood: *d* and *a* are small rollers, supported in the frame G H in a similar manner to the spindles. Their use is to confine the strap *a* to press against the rollers of the spindles with sufficient force to keep them all in motion.

The thread is taken up as fast as it is twisted by a reel K, which is turned by a wheel *h* and a pinion *i* upon the end of the principal spindle R. The threads are guided by passing through wire eyes fixed in an oval from L, which is supported in the frame of the machine by a single bar or rail *l l*; and this has a regular traversing motion backwards and forwards, by means of a crank or eccentric pin *k*, fixed in a small cog wheel, which is turned by a pinion upon the vertical axis E: the opposite end of the rail *l*, is supported upon a roller to make it move easily. By this means the guides are in constant motion, and lay the threads regularly upon the reel *k*, when it turns round and gathers up the silk upon it, as shown in the figure.

One of the spindles is shown at *r*, without a bobbin, but all the others are represented as being mounted, and in action. A bobbin is filled upon each spindle, by the hole through it being adapted to the conical form of the spindle, but in such a manner that the bobbin is at liberty to turn freely round upon the spindle. A piece of hard wood is stuck fast upon each spindle just above the bobbin, and has a small pin entering into a hole in the top of the spindle, so as to oblige it to revolve with the spindle. This piece of wood has the wire flyer *b* fixed to it: the flyer is formed into eyes at the two extremities; one is turned down, so as to stand opposite the middle of the bobbin *e*, and the other arm *b* is bent upwards, so that the eye is exactly over the centre of the spindle, and at a height of some inches above the top of the spindle.

The thread from the bobbin *c*, is passed through both eyes of this wire, and must evidently receive a twist when the spindle is turned; and at the same time by drawing up the thread through the upper eye *b* of the flyer, it will turn the bobbin round and unwind therefrom.

* This is taken from Rees's Cyclopædia, and is precisely the same as that represented in the French "Dictionary of Arts and Sciences," printed at Neufchatel, 1765, and in the Nouvelle Encyclopædie Methodique, Paris, 1786. The figures of the various parts, and the elevation of the machine, fill two folio pages. In France it is called an "ovale."

The rate at which the thread is drawn off from the bobbin, compared with the number of revolutions which the flyers make in the same time, determines the twist to be hard or soft, and this circumstance is regulated by the proportion of the wheel *h* to the pinion *i*, from which it receives motion; and these can be changed when it is required to spin different kinds of silk. The operation of the machine is very simple: the bobbins filled with silk in the winding machine, are put loose upon the spindles at *e*, and the flyers are stuck fast upon the stop of the spindles, the threads are conducted through the eyes of the flyers *b*, and of the layers L, and are then made fast to the reel K; upon which it will be seen, that there are double the number of skeins to that of the spindles represented, because one half of the number of spindles is on the opposite side of the oval frame, so that they are hidden. With this preparation, the machine is put in motion, and continues to spin the threads by the motion of the flyers, and to draw them off gradually from the bobbins until the skeins upon the reel are made up to the requisite lengths. This is known by a train wheel work at *n o p*, consisting of a pinion *n*, fixed upon the principal spindle R, turning a wheel *o*, which has a pinion fixed to it, and turning a larger wheel *p;* this has another wheel upon its spindle, with a pin fixed in it, which, at every revolution, raises a hammer, and strikes upon a bell *s*, to inform the attendant that the skeins are made up to a proper length. When this machine is employed for the first operation of twisting the organzine, the wheel *h* must be larger, and the pinion *i* smaller than is represented, in order that the reel K may be turned slowly, and the threads will thereby receive a stronger and closer twist. Also, the handle B is turned in an opposite direction to that in which it must move for the final throwing off the two or three twisted threads together: and, as it must also move for twisting the raw threads together for the warp of silk stuffs, and for weaving stockings, this reverse movement makes no alteration in the machine, except that it will give twist in a contrary direction; for it is always necessary, when two or more twisted threads are combined by twisting, that the twist of the original thread shall be in an opposite direction to that twist which unites them into one thread, in the same manner as for making ropes: organzine silk being in fact small rope, and stocking silk or warp being only yarn. The silk intended to be died is previously twisted very slightly in this machine; and of course in that direction which will suit the purpose for which it is ultimately intended; viz: whether for yarn or organzine.

Figure 3 represents a single spindle of a throwsting machine, G and H represent portions of the rails or circles of the stage which supports the spindle, and *a a* is a part of the rim of the great wheel of the central axle. This wheel is not made in segments, but is made very truly circular, and covered with leather on the edge, that it may act with more force to turn the roller *t* of the spindle. The point of the spindle rests in a glass lap, supported by the rail G, and the roller *t* is always made to press against the rim of the great wheel *a a*, by a small lever *d*, and a string, which, after turning over a pulley, has the weight

e made fast to it, to press the spindle always towards the wheel. In this machine the thread is taken up by a bobbin K, is put into a frame *m*, which moves on pivots, and by a weight *n* is pressed down, so as to make the bobbin bear upon the edge of the wheel *h*, which is kept in constant and regular motion by means of wheel work, which cannot be well described.

The intention is that the action of the wheel *h*, to turn the bobbin, being communicated by pressure against the part upon which the silk is to wind, will be constant, and will not draw more when the bobbin is large and full, or less when it is empty, as must be the case when the motion is given to the axis of the bobbin.

After the silk is twisted in a right hand direction, if it be intended for yarn or for dying; or in a left hand direction if it be prepared for organzine, it must be wound on fresh bobbins, with two or three threads together, preparatory to twisting them into one thread. This is done by women, who with hand wheels wind the threads from two or three large bobbins, upon which the silk is gathered instead of the reels, and assemble them two or three together, upon another bobbin of a proper size to be returned to the twisting mill. Machines are now in use for winding two or three threads together.

This operation is slightly represented and described in Rees's Cyclopædia, a work which has a general circulation in the United States.

The bobbins being filled with double or triple threads, are carried back to the throwsting machine, and are there twisted together: the manner of doing which does not differ from the operation before described.

In this second operation, the silk is taken up by reels instead of bobbins, and is thus made into skeins. The degree of twist varies with the purpose for which the silk is intended, and the wheels which give motion to the reels, are for this purpose adapted to the degree of twist which the silk is desired to have. The silk being spun, requires only the preparation of boiling, to discharge the gum, and to render the silk fit to receive the die. Figures 4 and 5 represent the zig-zag manner in which the silkworm spins the fibres of which the cocoon is formed. Figure 5 shows how the worm after working for some time in one part, will suddenly extend the silk fibre, and begin at another quarter.

IMPROVED ENGINE FOR TRAMMING SILK.*

By W. V. Shenton, of Winchester.

Transactions of the Society of Arts, London, Vol. 41, p. 169, 1823.

[*A silver medal was granted for this invention.*]

The only preparation which the raw silk imported into England has previously undergone, is that of being wound off the cocoons;

* One of these machines, imported by the Secretary of the Treasury, is now in his office.

but as the filament of the silkworm is of extreme tenuity, it is necessary, in the winding, to conjoin the filaments of from five to seven cocoons, in order to obtain a single thread of the requisite staple. The raw silk, thus composed, is still, however, too slender for the purposes of manufacture; and accordingly, the first process which it undergoes, is that of uniting two, three, or four threads into one, previously to giving it that kind of twist which is technically termed organzining.

The machine by which the union of the required number of threads is effected, is denominated a tramming engine, and admits of a considerable variety of structure: but the conditions absolutely essential in all, are the following: first, that the silk may pass off easily, and without entangling, from the delivering bobbins: secondly, that a small and equal degree of tension be applied to the threads as they pass from the delivering bobbins, to the receiving one, so that the compound threads shall be perfectly even; which obviously would not be the case, if one of the component threads were quite loose, while the others were drawn straight; thirdly, that the receiving bobbin ceases to revolve as soon as any one of the component threads happens to break—an accident which not unfrequently occurs; as, without such contrivance, a thread would be produced of variable thickness, from the casual omission of one or more of the component threads.

The operation of tramming, in some of the best constructed mills, is performed in the following manner:

The delivering bobbins (varying in number from two to four, according to the intended thickness of the component thread) are placed upon as many vertical spindles, the vertical position allowing the threads to quit the bobbins without any motion or revolution of the bobbins themselves. Some way above the bobbins, the threads pass singly between two horizontal slips of cloth or felt, which, by their friction, give at the same time a certain degree of tension to the threads, and clear them from any dust or other light matter. Each thread then passes through the eye of its own drop-wire, whence they all converge and unite in the eye of the guider, from which the compound thread is distributed on the surface of the receiving bobbin as it revolves. Each drop-wire consists of a piece of wire turned up, so as to form a right angle, of which the vertical leg is about two inches long, and is terminated by an eye through which the thread passes; and the horizontal leg is about four inches long, terminating likewise in an eye, through which passes a pin, connecting all the four drop-wires, and forming a pivot, on which each is capable of moving freely. Each thread, in passing through the eye of its drop-wire, slips down a little, and, being in a state of moderate tension, supports it at the elevation of half an inch or more above the position to which it would otherwise descend. When, therefore, a thread breaks, its drop-wire immediately falls, and strikes on the edge of a wire-frame, moving on a horizontal pivot, and so adjusted that the weight of the drop-wire immediately inclines downwards that side which it touches, and consequently raises the opposite side. To this opposite side a tail of wire is attached, which, when raised, catches on a kind of ratchet-wheel, fixed on the same spindle as the receiving

bobbin, and consequently stops it. The broken thread being repaired, is again passed through the eye of the drop-wire, and supports it above the frame; the opposite end of the frame then becomes preponderant; the tail, or stop, descends out of the way of the ratchet-wheel, and the revolution of the receiving bobbin immediately recommences.

This apparatus is very simple and efficacious, but is liable to two inconveniences; first, that the thread usually breaks close to the pieces of cloth by which it is compressed, and some trouble and loss of time are occasioned in drawing the thread out previous to tying it: secondly, that, when a smaller number of threads than four are trammed, the vacant drop-wires must be removed, otherwise their unsupported weight would, as above described, throw up the stop, and prevent the revolution of the receiving bobbin.

The contrivance by which Mr. Shenton effects the operation of tramming, and avoids the above-mentioned inconveniences, will be evident by referring to plate IV, of which figure 1 is an end view, and figure 2 a bird's-eye view of his machine—the same letters of reference denoting the same parts in all the figures; *a a*, the axis which gives motion to the receiving bobbins *f f*, by means of wooden rollers *d d;* they are made of any required length to suit a continued series of succeeding bobbins, with a roller under each; the wooden axis which carries the receiving bobbin, has a leaden roller *e* fixed on it, which receives motion by mere contact, on account of its weight. This axis is shown separate in figure 3; *p p* are two pins fixed in the leaden roller *e* ; *s*, another pin, or hook, which holds on the bobbin by hooking under the staple *t*, of the bobbin figures 3 and 4. As the receiving bobbin revolves, it draws the threads from two, three, or four bobbin *g g g g*, as previously determined; and in order to lessen the friction of these bobbins, which are fitted on wooden pins *u u u u*, the pins are perforated, and ride upon a wire *v*, and the bottom of these pins, and the loops which hold the wires, are rounded; leaving just friction enough to keep the threads extended. They are shown separate in figure 5. Now should any one of these threads break, it is requisite that the receiving bobbin should immediately stop; for this purpose, a crank-wire *m*, with a ketch *n*, and a fixed crank *o*, is placed near each roller; on this, four light drop-wires *k k k k* swing freely, and they have eyes to hang on the threads, which are their only support: these wires are shown a quarter their real size in figure 6. Now, should either of the threads break, the drop-wire which hung on it, would fall on the crank *o*, and cause the wire *m* to revolve, and bring the catch *n* forwards from its position, figure 8, to lay hold of the pin *p* of the roller *e*, as shown in figure 7, and stop it immediately; then, as soon as the thread is mended, the thumb is laid on the tails *w* of the drop-wires, to bring up the fallen one; the thread is then put in the eye, and the catch is withdrawn by turning back the end *m* of the crank wire, and the work goes on. There are two spare notches *x x* to lay the bobbin in, while joining the thread, that it may be out of geer, and move freely till set right by hand.

Now, the silk threads, on leaving the bobbins *g g g g*, pass separately

over a glass rod *i*, and through the eyes of the drop-wires, and then gather together in passing through the eye of the guide-wire *l*. In order to distribute equally over the bobbins the silk threads thus gathered together, an alternating motion is given to the sliding bar *c c*, which carries the guide-wires *l*, by means of a pin *r*, working in an oblique or spiral groove in the block *b*, fixed on the end of the axis *a*; and the obliquity of this groove corresponds with the length the silk is to be distributed on the bobbin, and therefore causes the sliding bar to move to and fro that length every turn of the wooden roller, or every four turns of the bobbin—the bobbin rollers being one quarter the size of the wooden rollers *d d*.

The bars *h h h h*, which support the supplying bobbins, are so placed as to make the bobbins stand at right angles with the thread when it passes from their middle to the glass rod. It is best to make the four eyes of the drop-wires lie parallel to the glass rod, as their vibrations on the threads will be more equal.

Figs. 8 and 9 show the tinned iron facings which are coiled round under the bars at *y*, to support the crank-wire.

Fig. 10 shows how the guide-wires are bent and fixed in the sliding bar.

q q, Fig. 2, are two sliding wires: it will be seen that where four threads are tramming, it is drawn back; but where two threads are tramming, it is pushed in to support the two drop-wires that are out of use, and prevent their acting on the crank-wire.

Fig. 11 shows the manner of riveting the wooden rollers on the axis, by cutting up a burr with a chisel on the angles *z z*.

Fig. 1 and 2 are a guard-rail.

Fig. 1 and 2 are one-sixth, the others are one-fourth the real size.

Improvement in the Silk Weaver's Draw Boy.—By Mr. E. Richards, of Bethnal Green.

Trans. Soc. Arts, London, vol. 40, p. 185.

In weaving plain goods, of every description, composed of silk, wool, hemp, cotton, or flax, the threads composing the warp are formed into two sets: the 1st, 3d, 5th, &c. forming one division, and the alternate ones, the 2d, 4th, 6th, &c. forming the other: each set is alternately raised and depressed, and at every crossing of the sets, the shuttle, containing a spindle full of thread, is shot, or thrown from one hand to the other, distributing the thread in its passage, in front of every intersection of the threads that compose the warp; but in figured silks, the threads of the warp are formed into more divisions than two—the number varying according to the pattern; and in order that each division may be raised or depressed with the necessary accuracy, each thread of the warp is passed through a loop in a vertical cord, furnished with a weight at bottom, to keep it properly stretched, and passing over a support at top. These vertical cords are called the monture, and are collected into as many sets or lashes as the pattern requires; it being understood that the cords of those threads which

are to be raised or lowered together, are to be included in the same lash. The number of lashes required for very simple patterns, on very narrow silks, is considerable, amounting to forty, sixty, or more. It is obviously, therefore, in these cases, impossible to give motion to the warp, by attaching a treadle to each lash. The way in which the lashes were actually raised, was to pass the end of each lash through a hole in a horizontal board, to fix to the lash a piece of wood like a bell-pull, and to employ a boy (thence called a draw-boy) in pulling or drawing down each lash in succession, so that the weaver had only to throw the shuttle and give directions to his boy.

Each cord of a lash having a weight hung to it, the aggregate weight of the whole lash is considerable, so that the labor incurred by the draw-boy was great, and considerable dexterity (the result alone of long practice) was required to prevent mistakes, and much loss of time. Hence the weavers were very dependant on their draw-boys, and the idleness or illness of one of them threw the weaver, for the time, out of work.

Various ineffectual attempts had been made to supersede the living draw-boy by machinery, but with little if any success, till Mr. Duff brought forward an engine for the purpose, which was rewarded by the Society of Arts in London, in 1810. Mr. Duff's engine, by means of a very ingenious contrivance, enables the weaver, by pressing alternately on two pair of treadles, to produce the regular elevation and depression of the lashes without the assistance of the boy.

The weight of the lashes, and the friction of the machine being considerable, it was necessary to adjust, accordingly, the length of the levers or treadles by which it was put in motion; in consequence of which, a tread of ten inches was thought necessary, that the weaver might not be oppressed by the weight.

It was soon, however, found, in practice, that the exertion of raising the feet ten inches for every motion of the treadle, was excessively fatiguing to the weaver, and apparently occasioned a predisposition to rupture, so that the machine came only into very limited use.

About two or three years ago, Mr. Jones, since dead, (an engine maker) attempted to shorten the tread, by fixing on the axis of the driving wheel two cranks, each about two thirds of the length of the radius of the wheel; but the mechanical disadvantage at which they worked, and the manner in which they were connected with the treadles, increased the weight and friction so disproportionately to the advantage gained by shortening the tread, as to render it wholly inapplicable in practice.

About last Christmas, (1822) Mr. Hughes, a weaver, fixed a small grooved wheel on the axis of the driving wheel, and connected it to the treadles by means of two cords passing over pulleys. It might be supposed that any advantage thus gained by shortening the tread, would be counterbalanced by the increased weight required to be overcome. This, however, is not practically the case. When the thigh of the weaver is raised, so as to be nearly horizontal, as necessarily happens at the commencement of a tread ten inches in height, the

muscular force which can be exerted by a given effort, is far inferior to that which an equal effort will produce in a tread of five inches; and hence, although the weight to be raised increases in proportion to the difference between the diameters of the driving wheel, and of the small wheel or pinion, yet the muscular advantage gained nearly counterbalances this increase of weight.

A real practical advantage, therefore, resulted from Hughes's invention, (although the mechanism employed is unnecessarily complicated, and not judiciously disposed,) since, by means of it, work which could not before be wrought by the machine, may now be performed by it.

In order to relieve the weaver still farther, by diminishing the weight on the treadle, and thus adapting the machine to heavier patterns and wider silks, Mr. Richards, in 1820, attached to the prolonged axis of the machine, an arm, carrying a leaden weight of such a magnitude as to counterbalance that of the lashes. The practical advantage of this contrivance, was, however, diminished by the weight being fixed in an inconvenient situation, and being liable to jar the machine; in consequence of which, in March, 1821, Mr. Hughes removed it from its original place, and fixed it within the frame, on one of the driving wheels. A still further improvement in its position, was subsequently made by Mr. Richards, who has prolonged the axis of the driving wheel, giving it the form of a quadrilateral prism, and, on any part of this axis, which local circumstances may point out as most convenient, the counter weight may be fixed by screws farther from, or nearer to, the centre of motion, according to the magnitude of the weight required to be counterpoised.

In order to render the above-mentioned improvement more intelligible, not only to the silk weaver, but to the public in general, it has been thought fit to give a representation, showing the connexion of the immediate subject of reward, with the whole apparatus for weaving silks as now employed in Spitalfields. The Committee of Correspondence and Papers were the more readily induced to adopt this measure, as, hitherto, no correct representation of the silk-loom and draw-boy had been published.

References to the engravings of a Silk Loom for weaving figured silk, with Mr. Richard's improvements on the Draw-Boy.

PLATE V.

Fig. 1 represents a cross-section of the draw-boy at the dotted line *a a*, fig. 2, with a side view of the loom, &c.

Fig. 2 is a section of the loom at the dotted line *b b*, fig. 1, together with a side view of the draw-boy.

Fig. 3 is a plan of the draw-boy, with part of its frame.

Fig. 4 is a longitudinal section of the axle, &c. of the draw-boy.

Fig. 5 is a cross-section of the axle of the draw-boy and figure box. Figures 1 and 2 are drawn to a scale of three-fourths of an inch to a foot; and figures 3, 4, and 5, to a scale of two inches to a foot.

The same letters of reference refer to the same parts in each figure. A A A is the frame of the loom; B, the roll or beam on which the warp is put; C, the cloth or breast roll; D D, the lay or bottom; E, the reed; F F, a frame which supports and regulates the table of mullets; G, the table, which consists of a number of thin bars, fixed in a frame nearly in a vertical position, but which can be elevated or inclined at pleasure, by a hoop H. Between each of these thin small bars, are placed one, two, three, or more, small mullets or pulleys *c c c*, over which pass the horizontal strings or tail *d d d*, by which the lambs or headles I I, J J, and K K, are suspended.

To weave plain cloth, only two leaves of headles are really necessary; but, in fine webs, where many threads are contained in the warp, the number of headles required in one shaft, would be so great, that they would be crowded together, which would cause unnecessary friction, and strain the warp. For this reason, a greater number of leaves is used in weaving figured silks, &c. The number of these leaves is so great, that the shafts on which the headles are placed, are obliged to be arranged in two, three, or more stages, one above another, as shown in figures 1 and 2, at I I, J J, K K; so that, when the lowest set of headle shafts I I, are raised to make the sheds, or opening in the warp, through which the shuttle passes, they are in the situation of those at *i i*, and do not rise so high as to interfere with those at J J; and, when those at J J are raised to *j j*, they do not interfere with those at K K; and those at K K will be raised to *k k*. So, by this arrangement, there will be three times the number of the leaves of headles, in nearly the same space, as when placed on the same level.

To each of the lower treadle shafts, are suspended three long small leaden weights *l l l*, so as to keep the treadles straight and perpendicular. The strings *d d d*, which suspend the treadles, are extended across the room, and are made fast to a horizontal rod L; which is also fixed by cords to the side of the room. M is a bar or roll, which is suspended from the ceiling of the room, to support the string or tail *d d*, &c. N is another roll, which is, itself, supported by a frame from the upper part of the loom, and supports the strings *d d*, &c., when the depression is made on them by the action of the foot on the treadles O O, P P, Q Q, from which the motion is communicated to the draw-boy, &c. R R is the frame of the draw-boy, which must be fixed to the floor.

S is a square wooden bar or axle of the draw-boy, mounted so as to turn backwards and forwards on two screwed centres *e e*, figures 2, 3, 4, fixed in the ends of the frame R R. There are also fixed to each end of the frame R R, and concentric to the axis of the screwed centres *e e*, a cylindrical ring *m* and *n*, figures 3, 4, of brass or iron. One end of each ring is made flat, with an internal flanch, for fixing it to the end of the frame, and the other ends of the rings are formed into inclined planes. On the upper side of the axle S are inserted, in two

parallel grooves, two wooden racks f and g, figure 3, so as to slide easily backwards and forwards. The upper edges of the racks have teeth similar to those of saws, but the inclined side of the teeth, in each rack, is in contrary directions. To one end of each rack is fixed a piece of brass o* and p, and rounded off on the end, so as to act smoothly on the circularly inclined planes m and n. Beneath the racks are concealed two spiral springs h h—the action of which tends to press the brass ends of the racks against the inclined planes m and n. T is the draw-boy or bow, seen best in figure 5, which consists of a semicircular piece of iron or brass, with a groove in the periphery, like a pulley; and each of its ends is divided, so as to form cleft hooks or claws, which clip the strings or lashes above the knots r r; so that, when the axle S is made to vibrate, the hooks q q first draw a lash or string on one side, and then on the other, alternately.

The draw-boy, or semicircle T, is fixed on a carriage U, called the figure box, which slides easily upon the axle S, and has two clicks, or catches s and t, in the inside of the box, with a string pressing on the upper side of each, and causing the clicks to act on the teeth of the racks, f and g. V is a roller, supported by its pivots, on the upper side of the carriage U, having the two pins, or levers u and v, fixed in it, opposite to each other, and projecting over the ends of clicks that act on the racks; on the upper side of each click, is fixed a hook or staple, which connects the clicks to the levers u and v, so that when the lever u is depressed, the click s is at liberty to act on the teeth of the rack f, and at the same instant, the lever will be raised, and disengage the click t from the rack g; and when the lever v is depressed, the click t will be at liberty to act on the teeth of the rack g, and the click s will be disengaged from the rack f; consequently, only one of the clicks can act on the racks at the same time. The roller V, is kept in either situation, by the action of a spring I, figures 3 4, fixed on the upper side of the figure box, or carriage U, and having a double inclined plane on the under side of it, near the point; the middle of which is situated over the pivot in the end of the roller V, and it acts on a small pin, which is fixed in the end of the roller, and on the upper side, and also over the centre of the pivot, when the lever u and v are horizontal; consequently when the lever u is depressed, the pin, in the end of the roller, will be turned in the same direction, and the inclined plane, nearest the point of the spring I, will retain it in that situation, till the lever v is depressed, which will cause the pin to raise the spring 3, and pass to the other side of the inclined plane, when it will again be detained till the carriage has arrived at the other end of the axle S. On the under side of the roller V, and at right angles to the levers u and v, is fixed another pin, or lever w, which passes through a hole, or a short slit in the middle of a small bar x, which is placed a little below, and at right angles to the axis of the roller, and also passes through each end of the box U, and is at liberty to slide backwards and forwards; so that when the box, or carriage U, has traversed over the number of teeth required in the rack, the end of the bar x comes in contact with a spring y.

* The letter o, does not appear in the original plate.—Editor.

, which is fixed on the axle S, between the racks,) and depresses it till it overcomes the resistance of the bar x, &c. which will be thrust forwards, and act on the pin as in the underside of the roller V, and also turn the roller in the same direction, as by depressing the lever v, which will disengage the click s, and engage the click t in the rack g: then the carriage will be in proper trim for traversing to the other end of the axle S, which is performed by the action given to the treadles, which is also communicated to the pulley 2, on the end of the axle S, and therefore causes the axle to vibrate half a turn, each motion of the treadles: as the axle is in the act of turning in the direction of the arrow, the circular inclined plane n, acts against the end of the rack g, and pushes it along the groove in the axle S, together with the carriage U, &c. equal to one notch or tooth of the rack; when the axle has returned half way, the spiral spring h presses back the rack g to its former situation, without moving the carriage U, on the axle S, (as the rack is at liberty to slide in that direction under the click, without butting against one of the teeth;) and by repeating another vibration of the axle, the carriage will be moved forward another tooth, one tooth each vibration, and so on, till the carriage has arrived at the other end of the axle S, then the other end of the bar x, will be brought in contact, and pushed against a spring z, (which is fixed on the upper side of the axle, between the racks, at any required distance from the spring y, between the racks, according to the number of strings or lashes r r, that the figure may require,) till the spring overcomes the resistance of the bar x, &c. which turns the roller V, and changes the action of the clicks s and t: then the carriage U will traverse back one tooth for each vibration of the axle S, by the action of the circular inclined plane m, on the rack f, till the end of the bar x comes in contact with the spring y, when the action of the clicks s and t will be again changed. The racks f and g, both slide backwards and forwards, the extent of a tooth, by the action of the two circular inclined planes m and n, for each vibration of the axle; but, as only one of the clicks is allowed to act on the rack at the same time, the motion of the other rack does not interrupt the progress of the carriage U, &c. The frame which contains the joint end of the click s, can be so adjusted by the screw 3, that the carriage U will be stopped by each vibration of the axle S, in a situation differing by half a tooth, according as it traverses one way or the other; so that a different set of strings or lashes r r, &c. will be drawn at each vibration of the axle, till the carriage U has traversed backwards and forwards on the axle S. W and X are two rails of wood, fixed on the upper side of the frame R R of the draw-boy, and parallel to the axle S; on the inner edge of the rails are fixed double the number of wire staples 4 4, &c. to that of the teeth in the rack f and g; the staples 4 4, &c. act as guides to the strings or lashes r r, which pass through them, and are fixed to the rail Y, which has four rows of holes, through which the strings r r, &c., are passed and retained by a knot on the under side of the rail; the number of holes is equal, and opposite to those of the staples 4 4, &c. and is also parallel to the axle S. In the end of the rails W and X are slits, through which the screws 5 pass, that fix them to

the frame; so that the staples 4 4, &c. in the rails, can be adjusted opposite to the groove in the periphery of the draw-boy; 6 6 are 2 thin rails, or false tail boards, which are also fixed on the upper side of the frame R R, and parallel to the rails W and X; the strings *r r*, being made fast to the rail Y, and passed through their respective staples 4 4, &c. have another set of strings tied to them at 10 10, called the false tails, which are passed over and through guide staples on the upper side of two smooth round rods, or arms 8 8, and then passed through the holes in the rails 6 6; and to the ends of the strings are appended small leaden weights, or lingots, 9 9, &c. which draw the strings *r r*, &c. so as always to keep them straight; one of the rods, or arms 8 8, is attached to the upper part of the frame of the loom, and the other ends are suspended by strings from the ceiling of the room; to the upper ends of each of the strings *r r*, at 11 11, is tied another series of smaller strings or lashes 12 12, the upper ends of which are also tied to certain horizontal strings *d d*, &c. which pass over the pulleys in the table G, and have the lambs or headles suspended from them: by this arrangement, it will be seen, that when one of the strings *r*, which is fastened to the rail Y, is pulled down, (by the action of the draw-boy, or bow, on the upper side of the string *r*,) it draws one of 10, lifts one of the weight 9, and raises such an arrangement of the lambs, or headles, as is proper to produce the figure which is to be woven.

When the draw-boy T, and axle S, are returned to the situation, as shown in fig. 5, the weights *l l l*, which are suspended from the lambs, and those at 9 9 will replace the lambs, lashes, &c. in their former situation.

In weaving heavy silks, or what is termed three, four, or more doubles, that is, so many double threads between each split of the reed, the power required to depress the treadles is so great that the weaver was obliged to have the assistance of a boy to turn a winch, which was fixed on the end of the axle S, which passed through the end frame of the draw-boy.

The application of the winch to the draw-boy, was the invention of John Sholl, who was rewarded by the Society of Arts, &c. in the year 1810.

Mr. Richards, being a machine or loom maker, observed the great difficulty of getting boys to attend their work, together with the expense, which caused him to turn his attention to the subject, and he has been successful in making the machine so perfect and powerful as to supersede the necessity of a boy.

The following are Mr. Richards' improvements on the draw-boy:

The power which is to be applied to the treadles O O, is communicated to the treadles P P, by the cords 13 13, and from the treadles P P to Q Q, by the cords 14 14; and from the treadles Q Q to the pulley 2, (which is represented by the dotted circle) by the cords 15 15, which are tied to the treadles Q Q, and passed over two small guide pulleys, the frames of which are affixed to a cross bar of the frame R R; then one of the cords is passed under, and the other over the pulley 2, and fixed to the heads of two screwed nails, which are

screwed into the grooves in the periphery of the pulley 2; the pulley 2 is fixed to the side of another pulley 18, eccentric to the axis of the axle S, by which means the power to turn the axle of the draw-boy increases as the treadles are depressed. Z, is another axle which turns on two conical steel centres, similar to those which support the axle S; to one end of the axle Z is fixed an iron wire 19, having a slit along it, through which a screw passes for fixing a weight 20, at any required distance from the centre of the axle; on the other end of the axle Z, is fixed a pulley 21, perpendicular to the pulley 18 on the axle S, each of which has two grooves on their respective peripheries; 22 and 23 are two cords, which are passed round the pulleys in contrary directions; the upper ends are fixed to the pulley 18 and the lower to 21; by which means the motion of the axle S is communicated to the axle Z. Now, suppose the treadles were level with each other, the weight 20 would be perpendicular above the axle Z, and would tend to turn it either way; consequently, as one of the treadles is depressed, the weight will pass to one side or the other of the axle, and its leverage power will be increased till the centre of gravity of the weight 20 has arrived horizontal with the axis of the axle Z; it will be obvious, that either by increasing the weight 20, or extending it further from the axle, the power will be increased; and by combining the eccentricity of the pulley 2, with the eccentricity of the weight 20, the power applied to the treadles may be increased so as to counterbalance any number of lambs or headles, and the weight appended to them, and to the false tail, together with the power required for raising or opening the warp for the shuttle to pass through.

Another of Mr. Richards' improvements, is the application, with certain modifications, of box 24, called the tabby box, which is fixed to the axle S, and has a semicircle 25 fixed to it, similar to the figure box, but without the clicks, &c. To the under part of the box 24, is fixed a wire rod 26, which passes easily through the figure box, and is supported by a staple 27, near the end of the axle, through both of which it is at liberty to slide to and fro.

28 and 29 are two sliding sockets, which can be fixed on the wire in any required place, by a set screw in the side of each.

The use of the tabby box is to raise a certain set of the lambs, or headles, to work the plain part of the silk, between the figures, without having so much lash tied to each of the strings, *r r*, &c. To adjust the tabby box for weaving figured cloth with a plain ground, the two sliding sockets 28 and 29 must be fixed on the wire rod 26, in their situations as shown in fig. 4; two strings, or lashes, must also be fixed, in a similar manner as those already described at *r r*, on each side of the axle opposite the tabby box, and passed through the staples 30 and 31; see fig. 3, (only part of the rails on one side of the axle which the staples are fixed in, is shown here, but the other side is fitted up in a similar manner.) Suppose the loom was already prepared to weave the figure as represented at fig. 6, and to commence at the line 30; the treadles being put in motion, will cause the axle to vibrate, the draw-

boy or bow T, on the figure box U, will draw every other string or lash r r, on each side of the axle S alternately, till the box U has arrived at the spring Z, and raises such an arrangement of the lambs, or headles, as is proper to produce the figures in the squares 33 33; at the same time the bow, or semicircle 25, on the tabby box, is drawing the strings or lashes 31 31, on each side of the axle alternately, and raises such an arrangement of the lambs as to produce the plain part of the cloth in the squares 34 34. At the instant the end of the small bar x, in the figure box U, comes in contact with the spring z, (on the upper side of the axle S,) the same end of the figure box on the under side of the axle also comes in contact with the socket 29, and at the next vibration of the axle, the rack g, will press the figure box U, together with the tabby box 24, forward on the axle, equal to one tooth of the rack, when the action of the clicks in the figure box will be changed, and the bow or semicircle 25, on the tabby box, will be opposite the staples which contain the strings or lashes 32 32, and will remain there, and draw the lashes on each side of the axle alternately, and raise such an arrangement of the lambs, as to produce the plain cloth in the squares 35 35; and at the same time, the figure box U will be traversing to the other end of the axle, and the semicircle T will be drawing the lashes r r, on each side of the axle, alternately, which it skipped when it traversed the other way; by which means, a new arrangement of the lambs will be raised, so as to produce the figures in the squares 36 36. When the other end of the small bar x shall be brought in contact with the spring y, at the same instant the end of the figure box will be in contact with the socket 28: and the next vibration of the axle will cause the rack F to push the figure box, together with the tabby box, along the axle S, equal to one tooth of the rack; then the tabby box, together with the wire rod and sockets, will be in their former situations, as shown in fig. 4; and the action of the clicks, in the figure box, will again be changed, and the whole figure completed. and the machine ready to produce a similar set of figures to those already described.

Improved Ribbon Loom.

In the 40th volume of the Transactions of the Society in London, for the Encouragement of Arts, Manufactures, and Commerce,* Mr. J. Thompson, of Coventry, gives a full and very minute account of his recent improvements on the ribbon loom, illustrated by four plates. The advantages stated to result from these, are—

1. It produces figures much finer than any loom heretofore made in England, and of larger size.

2. Eight treadles do the work of thirty-two treadles, in the common loom.

3. The common loom is limited to forty lashes, the improved one extends to 180 lashes; so that it is capable of producing work of greatly superior richness and fineness.

* London, 1823, p. 195

4. The common loom makes only one ribbon at a time, and produces at the rate of about $1\frac{1}{2}$ piece per week. Mr. T.'s make four at once.

Mr. T.'s loom allows the weaver to put any quantity of plain work that he pleases between the pattern, without changing the figure.

6. The weaver may instantly throw off the figure altogether, and produce plain ribbons, whenever work of this kind is required; whereas, all the present figure looms must continue making the particular figure for which they have been mounted. Fifty guineas and a gold medal, were presented to Mr. Thompson for this great improvement in the art of ribbon weaving.

In the 7th volume of the elaborate work by Borgnis, on arts and manufactures, there is another description of a ribbon loom, for weaving many pieces at the same time, with plates. The Nouvelle Encyclopedie Methodique contains ten double quarto plates, equivalent to twenty single plates of machinery, for the manufacture of several pieces of ribbon at once. It is probable that they represent the old machinery, but they may doubtless be referred to with advantage, as they are large and very distinct. These three works are in the library of the American Philosophical Society, Philadelphia, and may be consulted by artists, upon application to the Librarian, Mr. John Vaughan.

Improved French Looms.

In the year 1808, Mr. Jacquart, of Lyons, in France, invented a loom intended to do the work commonly effected by draw-boys, in the manufacture of figured stuff* for which he received a premium of 3,000 francs from the Society for the Encouragement of National Industry. This admirable invention remained unknown to the English until the year 1816, when it was seen by Mr. William Hale, and mentioned by him to several silk manufacturers; one of whom, Mr. Stephen Wilson went over to France, and introduced it into England, † with improvements. The loom is applicable alike to silk, cotton, woollen, and linen stuffs. The specification of Mr. W.'s patent is inserted in the Repertory of Arts, vol. 44, p. 257, with a plate. It is also described, but without a plate, in Borgnis' work, vol. 1, p. 267.

The great advantages of Jacquart's loom, consist in—

1. Enabling every plain weaver to become a figured weaver, to make goods which they have the greatest difficulty in making in Spitalfields.

2. In their being but one treadle. Instead of a number of treadles, or cords, which a boy stands to pull up and down, as in the common loom, the weaver has only to tread on that one treadle, and to throw the shuttle.

3. In enabling the weaver to change a pattern in a few minutes, while the common loom requires many days or weeks.

* That is, pulling down the cords, to work a number of treadles at a time.

† Minutes of the evidence taken before the Committee of the Lords on the Silk trade, June 25, 1823, p. 12. Do. July 3, 1823, p. 174.

The great superiority of this loom over the common kind, is further proved by the following facts: One man can make one hundred yards of figured stuff in twenty-five days. Mr. Stephen Wilson, who introduced this loom into England from France, in his examination before the Committee of the British House of Commons, on the silk trade, said, "here are a number of works that have been made with it, (producing a shawl;) this shawl has one thousand two hundred cords. I never knew of a loom of that number of cords in Spitalfields. Here is another work (producing another shawl) of six hundred cords; the weaver does all himself. It is also adapted for damask, which is one of the heaviest kinds of work. I always consider two yards and a half a good day's work for a weaver; and I have had made from three to four yards a day; and this is shot with worsted, which requires a stronger blow. Generally, they are drawn every four shoots; but this is drawn every shoot, which makes it a more difficult work : this pattern is three yards long, but it can be made of any length whatever. I have now a pattern going on with 7,000 lashes. If I am not too sanguine, my idea of this machinery is, that it is of as much consequence to the silk manufacture of this country, (England) as Arkwright's machine was to cotton ; and that it will supersede a great deal of the machinery now in use."

Le Brun's Loom.

Mr. Le Brun, of Lyons, has more recently invented a loom, with objects similar to those effected by Mr. Jacquart's apparatus. It is composed of five stages, and the mechanism, which is simple, allows one man to weave five pieces at the same time. Borgnis, speaking of it, says: "This apparatus is highly ingenious, easy of execution, and costs but little : it accomplishes fully the object of the inventor, without increasing the trouble of the workman, who is enabled to dispense with the aid of a draw-boy, as the machine performs his duty with the greatest precision. The harmony of the work, of the several parts, and the order of the design, are admirable."* Borgnis gives an outline of a description of Jacquart's and Le Brun's looms; but the utter impossibility of finding any who could translate the technical phrases into English, prevented its insertion.† A manufacturer of figured stuffs would be amply repaid by going to Paris to procure one of these looms, models of which are deposited in the Conservatoire des Arts et Metieres."

English Patents.

Philip Shell, of Kensington, for improvement in machinery for drawing, roving, and spinning hemp, flax, and waste silk‡—February. 1823.

* Vol. 1. p. 265.
† No dictionary contains the names of the numerous parts.
‡ Repertory of Patent Inventions, vol. 2d, p. 265: 1826

William Godman, of Coventry, for "new arrangement of the shuttles in the slays, as connected with the batton, and the suspending of the knotted parts of the lashes, on one set of shafts, to arrange with the same. This invention applies to that description of looms called "Dutch engine looms," employed to weave narrow articles"*—September, 1822.

T. Wm. Stansfield, of Leeds, for improvements in looms for weaving fabrics composed, in whole or in part, of woollen, worsted, cotton, linen, silk, or other material†—July, 1825.

Richard Badnall, Jun. of Leek, Staffordshire, for improvements in the manufacturing of silk, including the winding of silk, and for spinning, doubling, and throwing it, by one operation—July, 1825.‡

De Bergues' Power Loom.

In the London Register of Arts, vol. 3, p. 83,§ is a series of cuts representing this new loom, which was the subject of a lecture by the President of the London Mechanic Institution. It may be used either as a hand loom or a power loom, and is entirely composed of cast iron, with the exception of the axis, which, carrying all the moving eccentrics, or cams, requires great strength, and is of wrought iron. When used as a power loom, motion may be communicated to it by a wheel, which is turned by the hand, by steam, or water. A single wheel will give motion to several looms, and a steam engine will, of course, work a much larger number. The machine was worked before the audience. In two minutes, one inch and sixteenths of a web were manufactured. When worked as a power loom, by means of a fly-wheel, one of the silk threads broke, and the motion immediately ceased. The manner in which this was effected was described. One advantage of this loom is, that no inconvenience is ever experienced from the uncertain stroke of the lay and shuttle, as it is uniform and invariable. Another is, that one movement does the work, and one hand is sufficient to work it. Thus, a weaver with his family, may become a power loom weaver: for by a wheel in the corner of his room, and one child, or a laborer, to turn it, he can superintend two or more looms. The receding motion of the lay being slower than the advancing motion, (an advantage which is absolutely necessary for weaving silk,) gives a greater time to the shuttle to pass slower, and, consequently, enables the weaver to put a more tender shoot in his shuttle, or to weave a broader cloth. The shuttle will pass from 60 to 130 times per minute, according to the will of the weaver, and always with the same uniformity. Another recommendation is, the ease with which the weaver can regulate its different motions by tightening or loosening the pressing screws, on the only axis there used, by which the motion must always be uniform and regular, one part with another:

* Repertory of Patent Inventions, vol. 44, for 1824, p. 8.
† Do do vol. 2, for 1826, p. 96.
‡ Do do vol. 2, p. 227: 1826.
§ 1826.

to this may be added its probable durability, without repair; those parts which are most likely to be deranged will not require two shillings to repair them.

Kendall's Domestic Power Loom.

In the Register of Arts, vol. 3, p. 113, is a figure and description of this loom. It is said to be effectual and simple: a boy of twelve years of age, with a proper fly-wheel, will find no difficulty in turning six or eight of them when the work is plain. For rich works, an able weaver, with good materials, will be able to work two looms. The machine works steadily, and with few stickings. In one experiment, two pieces of silk were made, with a very slight application of the hand. It operates exactly as the common hand loom, and every description of fabrics can be woven by it. The arrangements preparatory to weaving are similar to those of a common loom.

The patentee resides at No. 8, Pater Noster Row, St. Paul's, London.

Patent to H. R. Fanshaw, London, silk-embosser, for his invention of improved apparatus for spinning, doubling and twisting, or throwing Silk.—Passed August 12, 1825.*

The subjects of this patent are described as consisting of four particulars; first, a new arrangement or disposition of vertical or horizontal bobbins, to be employed for the purpose of spinning and doubling silk: second, a new mode of forming the flyers, with double arms, for guiding the threads on to the bobbins: third, a contrivance for throwing the bobbins in and out of action; and fourth, a mode of retaining the horizontal bobbins against the bearing board. The annexed cut shows the arrangement of the several parts of the machine; *a a*, are the vertical bobbins, turning loosely upon the spindles *b b*, which, with the flyers *c c*, are made to revolve by means of the cords extending from the rotary pulley *d*. The silk passes from the bobbins *a*, upwards, through eyes *e*, over a glass rod *f*, between the drawing rollers *g*, which arrangement of the parts, so far, is the same as in ordinary machines for throwing silk.

The silk threads from the two or more bobbins *a a*, are delivered from the drawing rollers to the bobbin flyer of the horizontal bobbin *h*, which being turned by a cord from the before-mentioned pulley *d*, causes the silken threads to be doubled and wound upon the horizontal bobbin; the traversing of the bearing plate *i*, causing the bobbin to be slidden along the spindle, so that the silk shall be evenly wound upon the bobbin.

Such is the disposition of the machinery which, though not new in its separate parts, is herein claimed as new in its arrangement, and is employed in the way described for the production of organzine, or of

* From the London Journal of Arts and Sciences, by W. Newton, vol. xiii. p. 265

sewing silk; but, when another description of silk, called Bergam, is to be prepared, then only one of the vertical bobbins is to be put in operation, and another thread is to be drawn from the stationary bobbin *k*.

When very delicate threads are to be twisted, and doubled, it is proposed to use a flyer, similar to that shown at figure 2, with the ends turning down, and forming loops or eyes for the fine threads to pass through. In case of any of the threads breaking, it would be necessary to stop the bobbin connected with it. This is done by moving the lever *l*, which turns upon the fulcrum pin *m*, fixed in a stationary bar crossing the machine. This lever embraces a clutchbox *n*, attached to the rotary shaft on which the pulley *d* turns, and by moving the lever *l* to the right or left by the handle *o*, the pulley *d* is locked into gear, with the rotary shaft, or taken out of gear, and made stationary. As any sudden starting of the bobbins would endanger breaking the threads, it is contrived that the pulley *d*, shall be gradually put into gear, which is done by a circular inclined plane, on the face of the pulley, and a pin on the inner side of the clutch. The clutch being slidden by the lever towards the pulley, its pin moves upon the circular inclined plane until it comes to the end, and there, striking against the raised edge, carries the pulley round with it. The lever is held in its proper position by a spring catch at *o*.

The bobbin is held against the bearing board by a spring latch *p*, which falls into a groove at the foot of the bobbin. These new arrangements are deemed by the trade very important improvements.

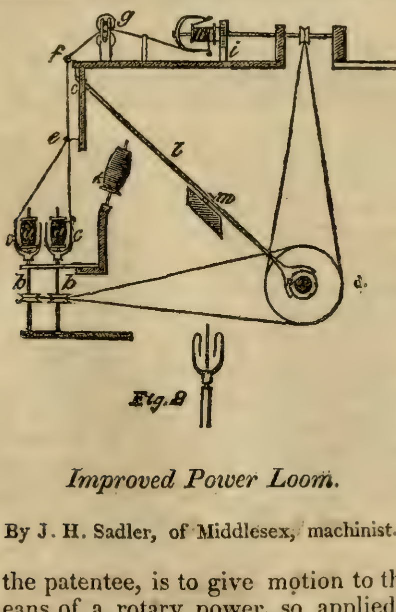


Fig. 2

Improved Power Loom.

By J. H. Sadler, of Middlesex, machinist.

The object of the patentee, is to give motion to the operative parts of a loom, by means of a rotary power, so applied, that its mechanism shall occupy no greater space than is required for the standing of an ordinary loom. To effect this object, the main rotary shaft, which

receives its motion from a steam-engine, or other first mover, is placed at the top of the loom; and, by means of cams and tappots affixed to the main shaft, the headles are moved up and down, which open the sheds of the warp; the lay or batten is made to oscillate, and the shuttle is projected to and fro, at the proper intervals of time.

This loom is also adapted to the weaving cotton, linen, wool, flax, and hemp, and mixtures thereof.* Plates accompany the specification.

American Winding, Doubling, and Twisting Machine.

The Messrs. Terhoeven, brothers, of Philadelphia county, have recently invented a simple and ingenious machine, for winding silk from cocoons, and for doubling and twisting the thread at the same time. These operations, it is believed, have never before been united in the same machine. It answers the object intended perfectly. A fringe weaver, who has seen the silk thread finished on this machine, pronounced it equal to any imported. The Board intrusted with the management of the fund left by the late John Scott, of Edinburgh, to the corporation of Philadelphia, for the distribution of premiums "to ingenious men and women, who make useful inventions and improvements," have awarded a medal and twenty dollars to the inventors.

Recent Improvement in Silk weaving.

Stephen Wilson, a silk manufacturer, when examined before the Committee of the House of Commons on the Silk Trade, July 3, 1823, stated, that the following improvement had been made in England and Scotland

In Scotland and Norwich they have shifting boxes, which save much trouble in changing the shuttles, so that a weaver can shoot different colors as fast as he could a single one. They have also lifting boxes. The shifting boxes are generally confined to three or four shuttles; the lifting boxes go as far as twelve or sixteen colors, which the weaver shoots with the fly, one after another. In Scotland they have also many improvements in weaving, which we know very little of in Spitalfields. They have what they call lappets, a quantity of needles that rise near the battens, and serve instead of brocading. They have also another very ingenious plan, which they call circles. In Spitalfields we brocade each of these figures with small shuttles, separately; but in Scotland the circles do all at one time, which is a great improvement in lessening labor. They have also what they call the cylinder or barrel weaving, which enables the weaver to dispense with a draw-boy in heavy works. And they have another method of weaving in the old damask loom, which is a very important one; and which is done by what they call a comb: this species of mounting is very much introduced for damask table cloth weaving. A gentleman

* London Journal of Arts and Sciences. By W. Newton. July, 1827.

from Westmoreland a few days ago, informed me he had a work making on this plan, with 14,000 lashes; that he had been in Spitalfields, and was surprised to see how far behind they were in damask weaving: for that they had no improvement upon the old looms. There is also a loom invented by Mr. Roberts, of Manchester, for which he has taken out a patent, of which I have heard a great deal, but have not seen it.

Question. Are the shawls you have produced, made by the improved machinery to which you have alluded?—They are; I never could get them made on the old plan; owing to the immense weight, and the quantity of lash, it never would work clear They are now made with one treadle, and the facility with which the weaver changes his pattern is such, that he makes four, five, and six different patterns in one week, besides changing his figure at the border.

*Method of preventing the watering of Silks without the use of a knee roll.**

There are two imperfections which silks, especially plain ones, are liable to acquire in the loom. One called cocklin, is merely an unevenness of the surface, and arises usually from one longitudinal edge or selvage of the piece being more stretched than the other, in consequence of its not being wrapped evenly round the roll or cylinder of the loom. The other imperfection, called watering, is a wavy or streaky appearance, produced by a play of light on the surface of the silk, though that surface may be quite smooth. The cause of this wavy appearance is not completely understood, but appears, in a great measure, to depend on unequal pressure being given to the piece while on the roll. It is well known that the highest polish and gloss is given to silk in the hank by twisting it hard, and, at the same time, giving it a kind of oscillating movement, so that each individual thread may be rubbed repeatedly on those with which it is in contact, whereby they mutually polish each other. Now, a piece of silk, in the process of manufacture, may be conceived to be placed in circumstances considerably favorable to the production of this partial polish, if, when rolled tight, and rather unevenly on the roll, it is subject to the vibration occasioned by the stroke of the lay upon the weft, which takes place after every throw of the shuttle.

The contrivance which used to be resorted to, in order to prevent the watering of silks, was by means of a knee roll. The five or six yards, which constitute an average day's work, being first rolled on the large or breast roller, during the weaving, were every evening transferred to a smaller roll, called, from its position, a knee roll. In doing this, great care was required to lay each fold precisely upon the preceding one, a manipulation that occupied about half an hour; and the silk, by frequent handling, was apt to become soft and less saleable. Of late years, attempts, more or less successful, have been made

* Trans. Society of Arts, London, vol. 42.

to avoid the use of the knee roll, by inserting a sheet of thin glazed pasteboard, at certain intervals between the folds of silk on the breast roll, which, from its elasticity, yields to the vibration of the loom, without communicating any motion to the silk, while its own smooth surface allows it to move a little on the surface of the silk, without any injurious friction. The most successful application of this contrivance, has been made by Mr. Peter Caron, which, although perhaps, in part, to be attributed to his own individual dexterity, (for, by the testimony of the foreman of Mr. Leveque, for whom he works, he appears to be a remarkably careful skilful weaver,) has been considered by the society worthy of being made public for the benefit of others in the same trade, both workmen and masters.

The process is the following:

After a porry (a quantity of five or six yards) has been wove, and rolled on the breast roll in the usual way, during the weaving, it is to be unrolled, and carefully rolled again as evenly as possible; a sheet of pasteboard, or pressers' paper, being put in the last turn. When a second porry has been finished, it is to be again rolled as above described, the sheet of pasteboard inserted in the last fold of the former porry, being first removed; but, at the end of every second porry, or twelve yards of work, the pasteboard which has been inserted is to remain until the piece is finished, especial care being taken that the pasteboard lies as close on the roll as the work itself does. Mr. Caron has practised this method for three years, and, during that time, has not had a piece in the slightest degree watered. The kinds of work to which it has been applied, have been Gros de Naples, Florentines, and double-twilled sarsnets.

Extracts from the Minutes of Evidence taken by Committees of both Houses of the Parliament of England, on the subject of the Silk trade and Silk manufacture, in the year 1821.*

Enoch Durant, a silk broker.—Silk is principally imported from Bengal, China, Italy, and Turkey. The average, of late years, amounts fully to a million eight hundred thousand pounds. Bengal sends about eight hundred thousand pounds, somewhat under; China about one

* When any subject of commerce, manufacture or internal improvement, is brought before Parliament, the House, instead of considering itself *ex officio* inspired, and fully competent to decide on the occasion, appoint a committee to examine and report on it, with authority to send for persons and papers. This committee, if they find it necessary, sit during the recess, and examine intelligent men, practically acquainted with the subject before them, from whom all the information requisite to elucidate it, is obtained; and, after a thorough and patient investigation of it, a bill, founded thereon, is brought forward. The minutes of the evidence are regularly published, to show the grounds of the provisions in the bill laid before the House. In this way the despatch of the public business is not only greatly promoted, but thousands of pounds are annually saved or gained to the nation, not in the way of daily pay, by preventing debates of weeks or months, (for the members receive no pay,) but by the proposed improvement taking place, or by a wise law going into speedy operation, or by the repeal of one which has been proved to be injurious to the prosperity of the country.

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TABLE of the rearing of Silkworms to the Sixth Age, from one ounce of Eggs.

AGES.		Space occupied by the worms on the feeding frames or hurdles. Feet.	In.	Temperature: Fahrenheit's scale.	Quantity of leaves. lb.	oz.	Total of leaves for each age. lbs.	OBSERVATIONS.
FIRST AGE	1st day	9	6	75°	0	14	7	Tender young leaves, chopped fine; four meals, progressively increased.
	2d do				1	6		" " " the first the largest, the last the smallest.
	3d do				3	0		" " " four meals.
	4th do				1	6		The first meal of 9 oz. the others less, if the leaves have not been eaten.
	5th do				0	6		Tender leaves, chopped fine. Worms casting their first skins.
SECOND AGE	1st day	19		73° to 75°	4	8	21	Half tender branches and half leaves, cut fine; the first meal twelve ounces, the other leaves in two meals.
	2d do				6	12		Tender leaves, four meals; the two first less than the two last. Enlarge the spaces.
	3d do				7	8		" " the two first the largest.
	4th do				2	4		" " distributed as wanted. Worms casting their second skins.
THIRD AGE	1st day	46		71° to 73°	6	12	69	Half tender branches, half leaves a little chopped; second meal 1 lb. 14 oz.
	2d do				21	8		Chopped leaves, four meals; the two first less than the two last. Enlarge the spaces.
	3d do				22	8		" " the two first the largest.
	4th do				12	8		" " " " the last, least.
	5th do				6	8		" " distributed as required. Third casting of their skins.
	6th do				"	"		" " " " Worms are roused.
FOURTH AGE	1st day	109		68° to 71°	23	4	210	9 lbs. of branches, 14 lbs. of leaves, cut coarsely; give the branches first.
	2d do				39	0		Leaves coarsely cut, four meals; the two first the smallest. Enlarge the spaces.
	3d do				52	8		" " three meals; the three first the least, the last 17 lbs. 4 oz.
	4th do				59	4		Whole leaves, four meals; the three first 16 lbs. 4 oz. the last 10½ lbs.
	5th do				29	4		Picked leaves distributed as wanted; the first meal the largest.
	6th do				6	12		" " " " Worms prepare to cast their skins.
	7th do				"	"		Leaves as wanted. Worms are roused.
FIFTH AGE	1st day	239		68° to 69°	42	0	1,281	Half branches and half leaves. Enlarge the spaces.
	2d do				65	10		Picked leaves, four meals; the first the smallest, 12 lbs. the last 22 lbs.
	3d do				93	0		" the first meal 22 lbs. the last 27 lbs. 12 ounces.
	4th do				130	0		" " 27 lbs. 12 oz. the last 37½ lbs.
	5th do				185	8		" " 37½ lbs. the second 46 lbs. 14 ounces.
	6th do				223	0		" four meals, the last the most abundant.
	7th do				214	0		" " the first meal the largest, the rest to lessen gradually.
	8th do				150	0		" four or five meals, the first the largest, 46 lbs. 14 ounces.
	9th do				120	14		" distributed as wanted. Worms approach maturity.
	10th do				56	4		" " " if not enough, give more.

The table is taken from the work by Bonafous, of Piedmont, on Silkworms. Lyons, 1824. The measures and weights are French. The French foot is divided into 12 inches, and the inch into 12 lines. It is nine lines more than the American foot, or one foot 7-100 American, nearly. Six French feet are six feet four inches American; twelve French feet are twelve feet nine inches American, fractions omitted; 93.89 French feet make 100 feet American. Those who intend to regulate the spaces by the rules of either Dandolo or Bonafous, may easily do so, by noting the dimensions of each hurdle or feeding frame. (See chap. 5.) It will be seen, by referring to chap. 13, that the spaces prescribed by Bonafous, are greater than those marked by Dandolo. The dimensions of this author, may be considered as a minimum, or the least that can be allowed, to secure the health of silkworms. It cannot be too often repeated, that the constant rule to be attended to, is to give the worms ample space, and never to permit them to be crowded. The spaces, as set down in the table, when reduced to American measure, are as follow, fractions omitted:

Feet.	Inches.	Feet.
9	6	10.
19		21
46		52
109		124
239		272

The quantities of leaves marked for the several days and ages, are those which have been found sufficient. The knowledge of the precise proportions may be useful, if a great quantity of worms be reared, when leaves are bought; or when persons are hired to collect them, by enabling the proprietor to make his contracts for the daily supplies; and by preventing the unnecessary waste of leaves, and surfeiting the worms, when he owns the trees. It should always be kept in mind, that, besides these reasons, a superabundance of food greatly increases the trouble of the attendants, from the litter it produces. The proportions prescribed by Bonafous, when reduced to American weights, are as follow, omitting fractions.

lbs.	lbs.	oz.
7	7	12
21	23	4
69	76	9
210	229	8
1,281	1,400	

In Chap. 8, it will be seen, that the weights of leaves are greater than those prescribed by Dandolo.

hundred thousand pounds; Turkey the same. The remainder comes from Italy—about eight hundred thousand pounds.

The duties on raw silk are as follow: Bengal 4*s*.; Italian, Turkey, and China, 5*s*. 7½*d*. per pound. Italian organzine, 14*s*. 6*d*. to 14*s*. 7½*d*. per pound. Prices paid for organzine silk in England, 7*s*. to 10*s*. per pound; the waste is from three to fifteen per cent. No organzine is made in France; they prepare their own trams and singles. China silk is applicable to hosiery—the Italian is not.

John Thorpe, ribbon manufacturer.—The price for making organzine in Italy, is from 3*s*. to 4*s*. per pound. There is a great difference in the size and goodness of the silk to work. In England it costs from 7*s*. to 10*s*. per pound to make it. The French are superior to the English in ribbons, but inferior in hosiery. China silk goods are heavier than English, but not of a better quality. The China raw silk is equal to most Italian, and better than any Bengal.

John De Ferre, a silk merchant.—In the Bengal silk there is a kind of cottony or fuzzy substance, which is thrown up into a pile or knap when woven. This is not perceived in the raw silk of Italy, France, or Turkey. The price of Bengal silk per pound, duty included, is from 14*s*. to 30*s*.; that of Italian raw silk, from 18*s*. to 35*s*.

Stephen Wilson, a silk manufacturer.—Nearly two millions of pounds weight of raw and thrown silks are annually imported into England; it gives employment to 40,000 hands, in throwing it for the weaver, and their wages are £350,000. Half a million pounds of soap and a large proportion of the most costly die stuffs, are consumed at a further expense of £300,000; and £265,000 more are paid to winders to prepare it. The number of looms may be taken at 40,000, and the weavers, warpers, mechanics, &c. will employ 80,000 more persons, and their wages will amount to £3,000,000. Including infants and dependants, 400,000 mouths will be fed by this manufacture; the amount of which I estimate at £10,000,000.

The price of dying white at Lyons, is fifteen sous, or seven pence half penny per pound; and colors 24 sous, or one shilling. In England the price of the first is 2*s*., and of the latter, from 2*s*. 6d. to 4*s*. The drawback on silk goods, in England, is 12*s*. per pound—ribbons 10*s*.

English silk goods are exported chiefly to the Brazils, and other parts of South America.

The labor in preparing raw silk, affords much more employment to the country producing it, than any other raw material.

The defect complained of in the Bengal silk, is in the preparation. There is nothing in the nature of the silk, which should not render it applicable to every purpose of Italian silk.

APPENDIX.

TREATISE ON DYING SILK.

To cleanse Silk.

This operation consists in depriving silk of the principles which affect its whiteness and flexibility. Monsieur Roard read before the Institute of France a very interesting memoir on this subject; of which the following is the result.*

1. That all unbleached yellow silk contains gum, coloring matter, wax, and a volatile odoriferous oil, analogous to essential oils, extracted from many vegetables.

2. That all white, unbleached silks, yield, also, gum, wax, and oil, slightly colored, which seems to bear some relation to the liquor contained in the chrysalis of the silkworm.

The gum is dry, friable, and, when powdered, is of a clear, yellowish, red color, soluble in water, but scarcely soluble in alcohol. It amounts to from 23 to 24 per cent. The coloring matter is resinous, of a reddish brown color, and of a beautiful yellowish green, when powdered, and of a strong odour; soluble in boiling soap and water, scarcely in caustic alkali. It exists in the proportion of from $\frac{1}{55}$ to $\frac{1}{60}$ per cent.

The wax is hard, but brittle, and slightly coloured: insoluble in water, but easily soluble in alkalies and soap. The fine silks of China, Saint Ambroix, and of Rocquemarre, have much less of this substance than the other unbleached silks of France, and especially those of Italy. The proportion of wax is from $\frac{1}{200}$ to $\frac{1}{300}$ of the weight of silk.

3. That the silks which yield the finest white, are the very white unbleached silks, and the yellow unbleached silks of a fine golden color: and that all the other silks, which are more or less dull, and in which the gum has undergone any change of condition, either by reason of sickness, or bad nutriment of the worms, or by the destruction of the chrysalis in too great a heat, or by winding, ill-conducted, will never attain more than a dull white, always somewhat colored, unless they be exposed, in the unbleached state, to the action of sulphureous gas.

4. That light bleaches the yellow and white silks, without altering their lustre, or their solidity; and that this agent may be employed to much advantage, either before or after they are cleansed. Four or five days exposure to the sun is sufficient to effect this object.

* Memoirs of the Institute, for the year 1808, (class of Mathematical and Physical Sciences,) vol viii. p. 552. It gives all the particulars of the experiments which led to the above interesting results. Monsieur Roard is a practical chemist, and was formerly director of the diers' department in the Gobelin manufactory of Paris.

5. That water, alcohol, the acids, and even the alkalies, do not entirely dissolve, equally well as the soap, the matters contained in the silk; and that this agent ought to continue to be exclusively preferred in the cleansing of silks, to all the above substances.

6. That the oxi-muriatic acid changes the properties of the gum, diminishes its affinity to water, and assimilates it to the resins, by rendering it soluble in alcohol.

7. That the silk, after being separated, by cleansing, from all the substances which concealed its whiteness and its brilliancy, loses afterwards in this bath, by the continued action of the soap, all the properties that it acquired by it; becoming dull, stiff, and colored, by the solution of more or less of its texture; a solution which is effected by all liquids, and which takes place even in boiling water. It is to this cause, hitherto unknown, that we must attribute the impossibility of impregnating the silks, whilst hot, with alum, and the destruction of a part of their brilliancy, in all the colors somewhat brown, for which we are obliged to employ the heat of boiling water.

8. That these great inconveniences may be obviated, by causing the silks to be boiled no longer than is necessary for cleansing them completely; and by submitting them only to moderate heats, in all the operations of dying.

9. That copper vessels cause some trouble, owing to the ease with which they oxidate, and discolor the silk, as has been shown in his memoir on aluming.

10. That it is highly important to employ very pure water, free from calcareous impregnation, but not in unnecessary quantities, in order not to increase the proportion of injurious salts, and not to weaken the force of the solvent.

The proper proportions for this operation, as ascertained after many experiments on a large scale, are seven or eight pounds of water to one of silk; and one-twelfth, or one-sixth, is sufficient for the greater number of colors: for yellow unbleached silks, and, above all, for those of Grenada (Spain) it is necessary to add from 50 to 60 per cent. The greatest quantities do not produce a very sensible effect upon those silks: for we cannot make them as white as those unbleached white silks cleansed with 25 per cent. of soap, even by the combined action of equal weights of soap and sulphureous gas.

11. Experiments have shown that all silks are completely cleansed in less than an hour; and that they lose their coloring and waxy matters, in proportion to the quantity of soap which the cleansing bath contained.

12. The operations of ungumming, boiling, and bleaching, which take up six hours, may be reduced to one operation, of an hour, with the same quantity of soap. I propose, then, the following method to cleanse silks. To boil, for an hour, all yellow and white silks, with five parts of water to one of silk, and a quantity of soap, which may be determined according to the colors intended to give them; to put the silks and soap in the water only half an hour before the moment of ebullition, taking care to turn them often. Long boiling causes the

silk to lose a portion of its substance, and, in doing so, it also loses its brilliancy and solidity.

Dr. Bancroft says, that "silk ought never to be subjected to a boil-"ing heat, either when the mordant is applied, or afterwards, in the "dying operation; where a high temperature, besides injuring the "texture and lustre of the silk, would detach and separate the mor-"dant before the coloring matter could have combined, and produced "an insoluble union with both."*

The injury of subjecting silk to a boiling heat, is further proved by the experiments of those eminent French chemists, Thenard and Roard, which show that "alumed silks take color more intensely when "they are died at a low temperature, than when they are plunged at "once into boiling water. The reason is, that, in the first case, the "action of the boiling water on the mordants is so quick, that the co-"loring matter has not time to be fixed on it, in order to give insolu-"bility to the combination; but, in the second case, this cannot take "place."†

Of ungumming and boiling Silk for white.‡

Make up the silk into hanks, that is to say, run a thread around each hank, which consists of a certain quantity of skeins tied together. After that, the hanks are to be untied, and several of them to be bound together to make up a bundle, the size and names whereof vary according to the nature of the article to be manufactured.

This precaution of making up into hanks is necessary, that the silk may be more easily managed, more conveniently handled, and to prevent them from being entangled.

After this operation, soap is to be dissolved in water, heated in a kettle, in the proportion of thirty pounds to every hundred weight of silk. (A dier of silk, to whom these directions were submitted, says, "that 15 lbs. of soap are enough for 100 lbs. of silk; more would "destroy its lustre." The kind of soap will cause difference in results.) Cut the soap into small slices, to promote its solution; after the soap has been dissolved, the kettle is to be filled up with fresh water, and the doors of the furnace closed, leaving only a few live coals in it, in order that the bath may be kept quite hot, but without boiling; for, should the bath boil, it would cause the silk to open, and to become flossy, more particularly the fine silk.

Whilst this bath is preparing, the hanks are to be put upon the pegs, or pins, and when the bath is ready, the silk is to be put into it, and left therein, until all the part dipped is wholly freed from its gum; which will be easily seen, by the whiteness and flexibility which the silk acquires when deprived of it. The hanks are then placed again on the rods, to undergo the same operation in the parts not yet steeped; they are then to be taken out of the bath, in proportion as they are

* Philosophy of Permanent Colors, vol. 1. p. 289.

† Annales de Chimie, June, 1810.

‡ Nouveau Manuel du Teinturier par Baillot, Maitre Teinturier.—Paris, 1810

found divested of their gum, because the hanks which have been first soaked, are always sooner freed from the gum than the other.

The silk, being thus ungummed, is to be wrung upon the pins to remove the soap in it; then to be dressed; that is to say, it is to be arranged upon the pins, and upon the hands, in order to disentangle it; then a cord is to be run through the hanks, to keep them down during the boiling: this is termed putting on the line. About eight or nine hanks may be placed upon a cord; after this, the silks are to be put into bags of strong coarse linen. These bags are to be fourteen or fifteen inches wide, and four or five feet long, and closed at both ends, but open the whole length of the side. When the silk is placed in them, they are to be stitched up the full length of the side with pack thread, which is to be knotted at the end when the sewing is done. From twenty-five to thirty pounds of silk are put into each bag: this operation is called bagging.

After this, a new soap bath is to be prepared like the former, with the same quantity of soap per cent.; and when it is dissolved, and the boiling stopped by means of fresh water, the bags are to be put into it, to undergo a strong boiling for a quarter of an hour; when it begins to boil over, it is to be checked by a little cold water. During the boil, care must be taken to stir often with a bar or staff, and to bring up to the top such bags as are at the bottom, to prevent the silk from burning, by lying too long at the bottom of the caldron. This movement causes the silk to boil with more uniformity and readiness. This operation is performed with silks which are to remain white.*

Of the boiling of Silks which are to be died.

For boiling silks intended for common colors, we put twenty pounds of soap to each cwt. of raw silk. The process of boiling is the same as the one just described, with this difference only, that, as the silk is not to be freed from its gum, the boiling is to continue three hours and a half, or four hours, taking care to fill up, from time to time, with water.

If the silks are intended to be died blue, or iron gray, sulphur, or other colors, which require to be set in a very deep white ground, in order to acquire the desired beauty, there are to be used thirty pounds

* The process for ungumming and boiling silk for white, is more full in Homassel, and may be seen in Dr. Cooper's work. The process for dying fine crimson is that long since published by Macquer, and is given by Dr. Cooper, Vitalis, Bergues, (*a*) and Baillot. The passage having been translated from the last author, and printed before this fact was discovered, it is retained; the receipt is probably the best extant.

Before diers condemn any process, they ought to reflect upon the following causes, which more or less influence their success. 1. The purity of the water. 2. The degree of heat to which it is raised. 3. The nature of the metal of the boiler. 4. Its state of cleanliness. 5. The length of time in which the article is boiled. 6. The quality of the vegetable die, as connected with its growth, preparation, time of drying the plant, the age of the infusion. 7. The purity of the mordant, and of the acids and salts used to fix it; mode of using them; the proportions used. 8. The state of the atmosphere when the dying process is going on. There may even be other causes, which contribute to success or defeat.

(*a*) L'Art du Teinturier, Paris, 1827.

of soap per hundred weight of silk, and the boiling is to continue, as before, during three or four hours. When the silks are boiled, they are to be taken out of the kettle. For this purpose, a stick is put under the bag, resting the stick on the edge of the kettle; and the bag raised gradually, and then to be placed upon a shelving table of white pine. It is then to be ripped or unstitched, and the silks taken out, in order to examine if they be well boiled, or if there be any part of them *biscuit*, (improperly so termed by the diers,) that is to say, if there be any parts which the liquid has not sufficiently penetrated. This is easily seen, by the yellow and a certain kind of slime remaining on those parts. Should this defect be discovered, they must be put in again, to boil during some hours; and when the silk is found to be well boiled, the bags are to be taken out, in the manner already described.

The silkc ommonly loses one-fourth of its weight in boiling; there are some silks, as the wefts in Spain, Valencia, &c., which lose two or three per cent. more.

Of White.

There are five sorts of white, or rather principal shades of white, which are called China white, India white, Paste white, or milk white, silver white, and blue azure white. All these kinds of white differ only by very slight shades, but which, however, are perceptible when compared with one another. The three first whites are boiled and freed from their gum, in the manner before described; but as to the silver white, and the blue white, it is proper to put some blue (azure) in the process of ungumming, which is done in the following manner. Some fine indigo is to be washed twice or thrice, in moderately hot water, then pounded in a mortar, boiling water poured over it, and left to settle till the gross parts of the indigo subside: the clear water only is used: this is what is termed azure by diers.

When the boiling goes on, the silk is to be stirred up and down, and moved round about by the means of the pot stick or half-bar; but, instead of placing the silk on a shelving table to drain, the bags are put into the long trough, (barque) full of clear water, opened, and taken out of it, leaving the silk behind. The silk is then spread out on a cord in the water, after which it is to be taken out and put on the shelving table, which is to be laid across the trough over which the silk is drained. After that it is to be dressed, and formed into hanks, in order to be wound or twisted. The bleeching is to be done as follows:

A large kettle is filled with clear water: to thirty buckets-full, about one pound and a half of soap are to be added and boiled, and when the soap is dissolved, the silk is to be put into the kettle on rods, and passed through it as follows: For the China white a little annotto is to be mixed with the bath, if we wish to have somewhat of a reddish tint. All the skeins arranged on the rods, are to be put into the bath, and the rods to be placed with their ends on each brim of the vessel.

the skeins hanging vertically in the bath; then, one after another, the other ends are to be turned and dipped, in order that the parts of the skeins which were out, may be soaked in their turn. This operation *(lisen)* is to be repeated until the silk shall have uniformly assumed the tint that we wish to give it. For the Indian white, a little azure is added, if it be desired to have the silk of a blueish cast.

With respect to the thread white, and the other whites, a little azure is added, in proportion to the shades which may be wanted. During the whole of this process, the bath should be hot, but not boiling; and the working is to be continued till the silk shall have acquired a uniform or equal shade, which is usually effected after four or five workings.

In proportion as the silks become equally finished, they are to be wrung upon the peg; after which, they are to be put upon the sticks in the drying room, or fumigated with sulphur, should it be necessary, as follows:

Sulphuring.

The silks which are to be sulphured, should be extended on poles placed at seven or eight feet from the ground, in a high apartment, without a chimney, or else a lofty garret where the air may freely circulate, by leaving the windows and doors open. For every hundred pounds of silk, nearly one pound and a half, or two pounds of roll brimstone are to be put into an earthen pan, or iron kettle, at the bottom of which a layer of ashes is to be placed. The rolls of brimstone are to be coarsely pounded, and placed in a heap upon the ashes; one of the bits of brimstone is to be lighted at a candle, and then applied to several parts of the heap to be set on fire. The apartment is then to be well closed; if there be a chimney in it, care must be taken to stop it up well, to prevent the fumes of the brimstone from escaping; the brimstone is to be left burning under the silk during the night. The next day, the door and windows are to be opened, in order to let the smell of the brimstone escape, and to dry the silk, which will suffice in summer.

In winter, after the smell is dissipated, the windows are to be closed, and live coals in chafing dishes, placed there to dry the silks.

The fumigation with brimstone gives a certain firmness to the silk.

There are stuffs which are always manufactured with raw silks, that is, silk reeled off dry from the cocoons, retaining all their gum and their natural stiffness, because those stuffs are designed to be firm: such as the silk laces, known in commerce by the name of blond laces, gauzes, and others of the kind; nor are these silks boiled; all the other preparations for dying, are however applied to them. But then those which are naturally the whitest must be chosen, and immersed in the water, then wrung and sulphured; and after that they must receive the azure in the clear water, be wrung again, and fumigated with brimstone the second time.

Experience has taught, that we may proceed as well by plunging them into the soap bath, as for the bleaching, and heated to such a degree that the hand may be kept in it.

They may be worked in this bath, adding a little azure to it, if necessary. When they are at the proper point, they are to be well washed in the river, which gives them the firmness they had lost in the soap water; afterwards they are to be wrung and sulphured.

The fine Nankin or China silks, which are naturally of a very fine white, are in no need of this operation.*

We owe to Beaume the discovery of a process by which the natural stiffness of the silk is preserved, while it is rendered perfectly similar to that of China, with which they manufacture gauzes, blond lace, ribbons, &c.

This process consists in digesting, for twelve hours, six pounds of silk, in a mixture of forty-eight pounds of alcohol, at thirty degrees, and 12 ounces of muriatic acid, at fifteen degrees of concentration.

This liquor is poured off when it has become slightly colored, and replaced with alcohol, which we pour over the silk until no more coloring matter passes off with it. It is then covered with a similar mixture of alcohol and acid, as at first, which is allowed to stand on it two or three days, or until the silk be perfectly white. It is then freed from any remains of the acid and alcohol, by washing it in cold water.

The silk bleached by this method and loosely dried, is without lustre. It ought to be strongly extended while dripping wet, and left to dry in this state of extension.†

Of Aluming.

After having washed the silks, and divested them of the soap by giving them a beetling, a line or cord is passed through them, as when they are put to boil. They are put into the alum, all strung together, taking care that the hanks be not too much rolled up, or folded upon one another, and that the bundles, (cordees,) be not too much in the air, or at the surface, so that the whole may be well steeped. They are to be left in this state during eight or nine hours, commonly from night till morning,‡ afterwards they are to be washed and wrung with the hand, over the vessel: they are then carried back to the river to be washed, which is called refreshing; and beetled when necessary.

The proportion of alum to be used, for a cask or tub of forty or fifty buckets full, is forty or fifty pounds, which should be first dissolved in a kettle of hot water; care must be taken, in pouring the solution of alum into the tub, to stir up and mix it, because the coldness of the water might produce a crystallization or congelation, as diers term it. We may put into such a bath about one hundred and fifty pounds of silk, without being under the necessity of adding more alum; but when we perceive that it begins to be weak, then there must be twenty or twenty-five pounds of alum dissolved in it, with the same precau-

* Baillot, p. 98.

† Chemistry applied to the Arts, by Chaptal, p. 422. Paris, 1807.

‡ A dier says that four hours of the alum steeping is enough.

tions as before given; and we should continue thus to add more alum, in proportion to the silks which are to be impregnated therewith, until the bath begins to have a bad smell; it is then to be drawn off, after steeping in it the silks intended for deep or dark colors, as brown, chestnut, &c. &c. and thrown away, the long trough (barque) cleaned, and a new bath to be got ready.

The silk must be steeped in the alum water whilst it is cold; if it were warm, the silk would lose its lustre.

Observations on Alum.

As alum has been emphatically termed the "soul of dying," it is of immense importance to use it in a state of purity; on this account the following remarks are given.

It is often combined with a portion of iron, which defeats the intention of the dier. To free it from this metal, Dr. Cooper* directs to "dissolve it in boiling water, and expose for a week or a fortnight in shallow vessels to the air. The iron will gradually be oxyded, and separate in the form of rust. Filter the solution, evaporate the water, and re-crystallize it." M. Vitalis directs to dissolve the alum, and crystalize it: pour off the liquor that remains, and dry the crystals on absorbent paper.

The presence of iron in alum is easily discovered by dissolving a small portion of this salt in distilled water, or in rain water, and adding a few drops of a solution of prussiate of potash. If the alum contains iron, a blue precipitate will immediately take place, which will be more or less deep, in proportion to the quantity of iron contained in the alum.

Alum varies much in its composition; sometimes it is an acid sulphate of alumine and potash: at others, in place of the latter, ammonia is found; and finally, both potash and ammonia enter into the compound, but although thus variously formed, it is equally proper for dying.* The regular form of alum is in octoedral crystals; and when thus found, it is a definite compound.

Inquiry has been made of the writer, as to the proper quantity of alkali to neutralize the excess in alum of sulphuric acid, which is injurious to colors. No positive quantity can be prescribed. The only certain mode to neutralize the acid, is to add a solution of alkali, until the earth of alum begins to precipitate. We may then be sure that the acid is fully neutralized.

The Indigo-Blue Vat.

For eight pounds of indigo, take six pounds of the best potash, from three to four ounces of madder, for each pound of potash, and eight pounds of bran, watered several times, in order to carry off its flour. When washed, press it to carry off most of its water, and place it at

* Treatise on Dying, page 25, Philadelphia, 1815.

† Vitalis, Cours Elementaire de Teinture, page 107—Paris, 1827

the bottom of the vat; boil the potash a quarter of an hour, in a kettle containing nearly the two-thirds of what it will hold; then leave it to settle, and put out the fire.

Two or three days previously, eight pounds of indigo should have been set to steep in about one bucket of hot water; in this, it is to be carefully washed, changing the water, which assumes a reddish color.

Some diers begin by boiling indigo in a ley made of one pound of potash, and two buckets of water: after which, it is to be pounded, wet as it is, in a mortar; when it begins to form a paste, some of the liquid just boiled is to be poured quite hot over it, till the mortar be full, and then rubbed for a certain time; the liquid is left to settle for some moments, and the clear part taken off and set apart in a kettle, or put into the vat; then pour an equal quantity of the boiled liquid over the indigo, remaining in the mortar, which is to be rubbed again, and the clear part taken off, and put into the kettle, as at first. Repeat this operation till the whole of the indigo be used, with the greatest part of the liquor of the bath. It is then to be poured by kettles-full over the bran in the bottom of the vat: then pour over it the rest of the *brevet* or refreshing liquor, with its sediment or grounds. The whole is then stirred or mixed with a stick, or wooden hoe, and left without fire, till the degree of its heat moderates, so as that we can bear the hand in the bath; then a little fire is to be set round the vat to keep up the same degree of warmth; it must continue thus till it be perceived that the liquor begins to turn green, which may be discovered by the help of a bit of white silk dipped in it.

When it is in a state indicating that the process goes on well, give it a stirring with a stick, or hoe, in order to forward it, and to see if it incline to be mature; then let it settle till a scum, or brown and coppery pellicle is seen rising to the surface, which shows that the bath is ready.

In order to be sure that it is ripe, observe if it be well crusted, and if, on blowing upon it, there be instantly a cream or scrum re-produced, instead of that which has been just set aside, it is then left to repose for three or four hours; after which make a new liquor: for this purpose the necessary quantity of water is to be put into a kettle, and boil in it two pounds of potash and four ounces of madder, as was done the first time; this new liquor is to be stirred up, then left to settle during four hours, at which time the tub is in a condition for dying.

Silk diers commonly have no other bath than that which has been just described; however, they might employ another for the green colors. This liquor is made like the preceding one, excepting that a half pound of madder is to be used for every pound of potash. This die is much greener than the former, and the color it gives is more lasting on silk, with a lustre equal to that given by the usual die. When the liquor of this vat has exhausted its coloring property, it becomes ruddy, like beer; whereas the liquor of the former becomes blackish.

The vat for the above quantity of indigo must be five feet deep, from two to two and a half diameter at the mouth, and from one to one foot and a half at the base, so as to resemble an inverted sugar loaf.

To make the different shades of blue, put into this new vat the shades intended to be the deepest; they are to be died by keeping them more or less time in it, in proportion as the liquor becomes weak, until it begins to be exhausted, and the shades which the silk takes, after having remained in it two or three minutes at most, begin to appear faint. When the liquor is so far weakened that it begins to lose its green, refresh it, to give it new strength, by a kettle-full of a decoction composed of one pound of pearl ash, two ounces of madder, and one handful of washed bran, boiled together for a quarter of an hour in water, or in a portion of the liquor in the vat, if it be still full enough for that. The liquor is to be stirred up, after these additions, and left to settle at least for two or three hours, before we begin to die with it. In order to die fine blues, it is proper to have a fresh vat: the light blues colored in this fresh weak liquor, are always more lively than those which are made in a liquor which has served for coloring deep blue.

Fine Crimson.

The silks intended to be died in crimson with cochineal, should be boiled in the proportion of twenty pounds of soap to an hundred pounds of silk, without any azure, because the slight yellow tint which remains in the silk, when it is freed from its gum, only with this quantity of soap, is favorable to this color.

After washing and beetling the silks at a stream, in order to clear them from the soap, they are to be put into the alum solution in its full strength; and left in it from night till morning, or about seven or eight hours. After this, the silks are to be washed, and twice beetled at the river. During this interval, the bath is to be prepared in the following manner: The long trough is charged with river water, about one-half, or two-thirds, and, when boiling, some gall-nuts, powdered are to be put into it, and suffered to boil for a while; then put from four drachms to two ounces of them for every pound of silk; if the gall-nuts are pounded very fine, and passed through a hair-sieve, they may be put in at the same time with the cochineal.

When the silks are washed and beetled, they are to be put upon rods by hanks: these hanks may be thick, because the crimson color is not subject to be unequally set. The cochineal, pounded and sifted, is then to be thrown into the bath, and well stirred, and must receive five or six boils; from two to three ounces for each pound of silk, are to be put in, according to the required shade. In order to give the most common shade or color, the proportion of cochineal is two ounces and a half: there are seldom put more than three ounces, except when one dies some particular variety.

These ingredients are to be put into clear, pure, and soft water, in a kettle of pure tin, and not of copper, or brass tinned. This is a rule from which the diers of the British East India Company never deviate. When the cochineal and the galls have undergone a boiling, put into the bath, for every pound of cochineal, one ounce of a solution of tin in *aqua regia*, called composition, which is made in the follow-

ing manner: one pound of spirits of nitre, (nitric acid,) two ounces of sal ammoniac, six ounces of grain tin. The tin, and the sal ammoniac, are to be put into a sand-stone pot of sufficient capacity; upon these pour about twelve ounces of water, then add the spirits of nitre, and let the solution take place.

This composition contains much more sal ammoniac and of tin, than that which is employed for the scarlet of cochineal upon wool. The composition is added in the proportion of one ounce to a pound of silk, when the galls and the cochineal have been made to boil. The kettle is left to cool a little, by opening the door of the furnace or stove: the silk is put into the vat, and to be worked from five to seven times; after this, the bath must boil during two hours: in that time, care must be taken to work the silks now and then. At the expiration of this time, the fire is to be withdrawn, and the silks are to be wholly immersed; they are to be left there five or six hours, and even if the crimson be died in the evening, they may be left in it till the next morning. By this means they receive a fine half die: they are to be washed, and to get two beetlings, wrung as usual, and then spread upon the perches to be dried.

Chaptal says, that, by giving silk a ground of yellow, before dying it in the above manner, a poppy, or flame color, may be obtained, as handsome, and more solid and economical than that produced by the use of the carthamus, or bastard saffron.*

Of Green.

This color is composed of yellow and blue: it is difficult to give it to silk, by reason of the inconvenience attending the blue bath, which is subject to be checkered, or to take a variegated color which becomes still more perceptible in the green than in the pure blue. In place of applying the yellow on the blue, we give the blue upon the yellow, and proceed thus:

The boiling of the silk for these colors is the same as for the common colors. After the silk is boiled, it is to be well impregnated with the aluminous water, then rinsed in the river, and distributed in little hanks of four or five ounces. This precaution is necessary to give the yellow ground to all silks in general which are intended to be died green; because the silk being thus distributed, has the advantage of being uniformly died. Weld† is to be boiled as for the yellow, (which see:) and a bath of it prepared with clear water, and to be so strong as to give a good ground of lemon color. The silk is to be worked in the bath, with great attention, because the inequality of color in the ground is easily perceptible in the green: and when we judge that the ground is nearly at its height, some fibres of the silk should be dipped, in order to see whether the color has sufficient plenitude or ground: if it has not enough, add the decoction of weld, and make a new trial.

* Chemistry applied to the Arts, p. 466.
† Dier's weld—Reseda Luteola.

When the color takes well, the silk is to be wrung, washed in a stream and beetled, if it be thought proper. The silk is then to be dressed, re-formed into hanks suitable for the vat, then steeped, one hank after another, in the blue vat; finally, wrung and dried with care and celerity.

The fifteen or sixteen clearest shades of this kind of green, need only to be steeped in the vat, in order to be entirely completed.

For the Pistachio green, if the vat be too strong, air the hank, when taking it out, without washing it, clap it with the hands; that is, holding it in one hand, and clapping it lengthwise with the other, to separate the threads, and thus receive the air, which causes the color to brighten uniformly: some threads are to be washed, in order to prove whether the color be good: the silk is then washed. For deeper greens, of this shade, add to the weld a decoction of logwood, or of Venice sumach.

For very deep greens, such as duck-green and bottle-green, add a little copperas.* The apple-green and sea-green, require a light yellow. We shall be less liable to give too deep a shade of yellow, by taking the precaution to die in the weld baths, which have already been used, for the silk being strongly alumed, will be apt to take too strong a hue in the new bath. Raw silk, reeled off dry, (*soie crue*,) is died precisely in the same manner, after having been immersed.†

Lilac.

As lilac is a very light and brilliant tint of the violet, or of the purple, we must apply the blue with much caution, or sparingly; and, as commonly the baths are too strong, it is the custom to mix a little of the fresh or new bath, with some potash in clear cold water, in order to prepare a bath on purpose for blueing the lilacs at will.

When the liquor has been put into the bath, it is to be immediately stirred up, then it assumes a green color which imperceptibly diminishes; we wait till the bath begins to lose a little of its first green color, and approaches to that of indigo, in order to put the silks into it. The potash helps to make the archil blue, because it is in general the effect of all the alkalies to render every red more of a violet tint.

Another Process.

The process consists in employing the chemical blue with a quantity of archil, in proportion to the intensity of the die that is desired.

Violet with Logwood.

Take died silks impregnated with the alum water, and washed in the usual way, boil water with logwood chips, as done with respect to Brazil wood: it is destined to give a blue.

* Baillot, page 115.

† Vitalis: Cours Elementaire de Teinture, p. 502.

This die ought to be made cold, because, when the logwood is warm, the color it gives is spotted and not equal; besides it is much more dull and less handsome.

The decoction cannot be preserved more than three weeks or a month.

Violet with Brazil wood and Logwood.

To make this violet, the alumed silks, after being rinsed, as common, are put into a bath of Brazil wood of the usual degree of heat, and after they have undergone this bath, add a decoction of logwood, and work them therein, and when the color is as full as desired, add to the bath a little potash ley; then wash the silks, wring and dry in the usual manner.

If we begin by the logwood, we should use the bath cold, on account of the uneven die it gives when it is hot, and which it is even subject to produce when taken from the bath and exposed to heat. This does not take place in the method we have given for it: for it is not necessary to give the logwood a cooling by this process, because the silks are impregnated with the die of the Brazil wood.

Instead of putting the potash into the bath, it is sometimes proper to make a bath of alum, with clear water, for the alteration of the tint. This ought to be adopted when we apprehend the silks may be too much charged with the die, by leaving them long in the bath.

Violet with the Brazil wood and Archil.

After having boiled and impregnated the silk with the alum water, it is to be put into a bath, more or less clear, of Brazil wood, according to the shade intended to be given; and, when it is taken out, the silk is to be beetled in a river, then to be put into a bath of archil, in order to complete the color. It is to be washed a second time, and to receive a beetling. After this it is to be put into the blue vat, then wrung and dried with the same despatch and precision as the greens and blues.

Of Yellow on Silk in hanks.

Silk destined to be died yellow, is boiled in the proportion of twenty pounds of soap to each hundred pounds of silk.

After the boiling, it is to be washed and put into the alum, and after being washed again, as usual, (called refreshing,) and dressed; then to be put upon rods in hanks, of about seven or eight ounces each, and worked in the yellow bath.

For dying clear yellow, *(jaune franc,)* called by diers yellow in grain, they commonly employ no other ingredient than weld.

Put into the caldron about two pounds of weld to each pound of silk; and, in order that the bunches of the plant may mix well with the water, lay on them large blocks of wood. After a quarter of an hour of boiling, the bath is to be strained, and left to cool till the hand can be borne in

it; then put in the silk, and work it therein until it become of an even color. If the liquor be not enough to fill the long trough (barque,) add water, and before the bath is cold, so that there may be the same degree of heat mentioned above. In general, all the long troughs or caldrons, in which dying is to be effected, should be full; the silk being plunged in, till about two inches distance from their brims. Whilst this operation is going on, weld is to be boiled a second time in a new water, and then taken out at one end of the long trough, and placed on a shelving white pine table, or else on the top of the trough. Then about one-half of the bath is to be thrown out, and to be supplied with the second liquor from the new bath of the plant, in the same quantity that has been taken from the first, taking care to stir up the bath, in order to mix the whole well. This new bath may be employed somewhat hotter than the first; still, however, the heat must only be moderate, because, if it were otherwise, we would destroy one part of the color which the silk had already taken.

Work in this new bath, as on the former occasion; and, during this time, dissolve potash, in the proportion of about one pound for twenty pounds of silk. For this purpose, put the potash into a small kettle, then pour into it some of the second weld liquor boiling hot, stirring up the potash. This little bath is to be left to settle, and when it is clear, lift out a second time the silks, putting them on the shelving table, and throw into the bath two or three ladles-full of the clearest part of the potash water. The bath is to be well stirred up, and the silks to be dipped again, and worked* anew. After seven or eight workings, one of the hanks is to be wrung upon the pin, in order to see whether the color be full enough, and of a proper yellow. If it be not sufficiently so, add again a little of the potash bath, and proceed as directed above, until the silk receives the desired shade.

To die a yellow approaching to that of Jonquille, at the time of putting the potash into the bath, we must add also to it some annotto, in proportion to the color required.

The slight shades of yellow, such as pale lemon, or Canary bird color, ought to be made on a very white ground; for this purpose, the silks are to be boiled with thirty pounds of soap for every hundred weight of silk. If they be not sufficiently blued (azured) for giving them these shades, some ladles-full are to be taken out of the bath of boiled weld, and some mixed with clear water, with a small portion of the liquor of the vat. The silks are then to be put into this bath, and steeped and washed as usual; and, if it be perceived that the shade is not deep enough, some of the weld liquor must be added, and from the vat also, till the desired shade is obtained.

For the deeper shades of lemon color, boil the weld the same way as for the yellow, and add a certain quantity of it to clear water, in proportion to the desired fulness. Put into it also some of the liquor in the tub, if the shade require it: but the deep lemon colors may be boiled in the usual way like the yellows. It must be noted that the

* In the edition for the House of Representatives, these words were improperly printed, "washed," and "washes."—Editor.

blue is not to be added from the vat in these colors, except only when we desire to have a greenish tint. These shades are often liable to be too deep, when they are impregnated with too much alum. In order to avoid this inconvenience, instead of applying the alum like the others, we may make apart for them a weak and small alum bath, in which they may be worked; or else, without giving the alum water separately, only a little alum may be put into the same weld-bath.

To die Blue.

The following proportions of the articles necessary for a cold blue vat, were given by an extensive silk dier of Philadelphia.*

"One pound of indigo to every pound of copperas: to 120 gallons of water, add 16 pounds of lime, and 6 pounds of indigo."

Blue. By Mons. Raymond.†

Previously to the year 1811, the silks died blue were dull; but, in that year, M. Raymond invented a method of giving silk a deep and brilliant color, which is now generally adopted, and is known by his name. Here follows the process. When the silk has been cleansed, immerse it for a quarter of an hour, at the ordinary temperature, in water containing about one-twentieth part of its weight of the sulphate of the peroxide of iron,‡ wash, and hold it for half an hour in a bath, nearly boiling, of soap and water; wash it again, and put it in a cold and very weak solution of prussiate of potash, soured by sulphuric acid, or by muriatic acid. As soon as it is immersed, it becomes blue, and nothing more is wanting, than, in about a quarter of an hour, to wash and dry it. In this operation, the silk imbibes a certain quantity of feruginous salt; the soap in the water destroys or neutralizes the acid of this salt; the sulphuric acid, or the muriatic acid, unites with the potash of the prussiate of potash, and the prussic acid is transferred upon the oxide of iron retained by the silk.

Silk thus died becomes dull in time, when much exposed to the sun, but will regain its brilliancy by being kept in the dark.

Chaptal says, in order to obtain the Turkish blue, which is the deepest of all, it is necessary to immerse the silks in a very strong warm bath of savory, before putting it into the vat.

* The late Mr. John Dougal.

† Traite de Chimie, par J. L. Thenard, tom. 4, p. 214. Paris, 1826.

‡ According to Thenard, the sulphate of the peroxide of iron is procured in the following mode:

"Expose a solution of green copperas to the air: it then slowly absorbs oxygen, and the sulphate of the peroxide is precipitated in the form of a yellow powder: the neutral sulphate of the peroxide remains in the solution, to which it gives a red tinge."

A manufacturer of Prussian blue, in Philadelphia, procures it in this way: dry copperas, by exposing it to a heat; then submit it to a more violent heat, until it is converted into a grayish red-colored substance, which is the red oxide of iron, combined with a portion of the red sulphate. As it is deliquescent, it must be carefully kept from the air until it is about to be used.

When our object is to obtain the royal blue, which is also very deep and permanent, cochineal is employed in place of savory.

This last blue may be successfully imitated, by first immersing the silk in a solution of 1 oz. 7½ drs. of verdigris, to 1 lb. 4 oz. 4 drs. of silk; the silk is afterwards disposed in a bath of logwood, in which it assumes a blue color, which is fixed by passing it through the vat.

Silk to be died blue, is usually boiled in a bath composed of 44 lb. 2 oz. 4 drs. of soap, to 110 lb. 5 oz. 10 drs. of silk; it is carefully washed, and twice put through running water, after which it is made up into skeins, and plunged into the vat by means of the wooden roller, until it has acquired the desired shade. It is then wrung by the hand, shaken out in the air, afterwards washed, and again wrung and hung up to dry.

When silk is to be died blue without boiling, the whitest kinds are chosen; they are dipped in water with a view of disposing them more readily to imbibe the die.

*Yellow.**

Alum, 3 oz. to 1 pound of silk; sugar of lead, 1 oz. to one pound of alum; fustic, one pound, to one of silk; water, one or two gallons, in proportion to the required shade. Immerse the silk over night in the solution of alum and sugar of lead, take it out, wring and die it in the fustic: the high price of weld† prevents the use of it; when used, the proportion is the same as that of fustic.

Chaptal says, that silk intended for a yellow color, is boiled with 22 lbs. 1 oz. 1 dr. of soap, to 110 lbs. 5 oz. 10 drs. of silk; it is afterwards washed, alumed, and put on the rods.

The yellow bath is prepared by boiling 2 lbs. 3 oz. 5 drs. of weld to the pound of silk, during a quarter of an hour. This bath is strained through a sieve, and cooled until the hand can be kept in it, before the silk is immersed in the vat.

The weld is boiled a second time, with a fresh portion of water, and employed to supply the waste, and keep up the heat of the first bath, into which more silk is put until it be sufficiently exhausted.

With the view of extracting every particle of color from the weld,‡ and of imparting a golden hue to the yellow produced by it, 1 lb. 4 oz. 4 drs. of potash, to 22 lbs. 1 oz. 2 drs. of silk, are put into a caldron; the second bath of weld is poured boiling hot on these ashes, and well stirred, to hasten the solution. When the bath is become clear, they gradually transfer a portion of it to the first bath, and after stirring it again, immerse the silk. A golden hue may be imparted to yellow by means of annotto.§

The United States abound in vegetables producing a yellow color, and, with proper mordants, may be found highly valuable.

* Mr. John Dougal.
† The weld plant should be cultivated by our farmers: no crop will pay better.
‡ Absurdly called "woad," in the London translation of Chaptal.
§ Chemistry applied to the Arts, p. 484.

The following are worthy of serious attention:—

1. Xanthoriza *Apiifolia*, or x. *tinctoria*, parsley-leaved root, yellow root. See Dr. Woodhouse's experiments on this plant in the Domestic Encyclopedia, article Xanthoriza.

2. Hydrastis *Canadensis*, yellow root. The simple tincture of the roots imparts to silk a rich yellow, and, with an appropriate mordant, might be permanently fixed.

3. Hopea *tinctoria*, horse laurel, horse honey, yellow leaf. This tree abounds in the low parts of Virginia, in West Tennessee, the upper parts of North and South Carolina, Georgia, and, according to Michaux, generally in the limits of the pine barrens.*

This author says, that, with alum, it dies a beautiful yellow on wool and cotton; it would doubtless succeed equally well on silk. The leaves only are used. Dr. Ramsay† says, that the late Mr. Felder, of Orangeburg, procured a paste from the leaves, and those of a species of *cassia*, called yellow indigo, for which he obtained a guinea per pound, during the American war. Unfortunately the process died with him. Dr. R. mentions several other plants, which yield a yellow color.

4. Bow wood, yellow wood, Osage apple tree: Maclura *Aurantiaca*. This abounds in Missouri,‡ and, according to Mr. Nuttal,§ also, in the Arkansas Territory, near Style's farm, a few miles from the Kiamesha river, on the great prairie.

5. Hypericum *perforatum*, St. John's wort. This plant is not a native of the United States, but like the pretty, but troublesome weed ransted, was imported from Europe, and has become a pest to the farmers of Pennsylvania. The flowers and summits, filled in with seeds, contain a juice, soluble in water, in spirit of wine, and vinegar. It diffuses through the first two liquids a red color, and in the latter a most splendid crimson: when combined with acids or metallic solutions, it presents a beautiful yellow color.

To die cloth, wool, silk, and cotton, yellow, it is sufficient to immerse them in water, properly impregnated with the juice of this plant, and a certain quantity of mordant. The best mordant is alum and potash, in which the stuffs are to remain for some time: for it is on the length of the time, the quantity of mordant, and the heat employed, that the fixity of the color, and the shades resulting from it, depend. When little mordant is used, the die is of a *yellow* color; by increasing the mordant, it inclines to green, and, by adding a solution of tin in nitro-muriatic acid, it assumes rose, cherry, and crimson shades, all very beautiful. The alum generally employed for all extractive dies does not succeed well in the process here alluded to; the addition of potash is essentially necessary,‖ because it decomposes this salt, precipitates its earth, dissolves a considerable portion of it, and it is this alkaline

* North American Sylva, vol. 3, p. 54. It also abounds in the Mississippi State.

† History of South Carolina, vol. 2, p. 249.

‡ Bradbury's Travels.

§ Nuttal's Travels.

‖ See note on Alum.

salt, with an earthy base, which, in this operation, becomes the true mordant, especially as the coloring principle resides in a matter almost purely resinous.

The juice of St. John's wort, united to the mordant here mentioned, gives to paper a beautiful yellow color, and to skins."*

The comparative merits of the foregoing yellow dies with one another, and with the inestimable quercitron bark, may be tried by practical diers.

Poppy.

The poppy color is procured by precipitating the red of bastard saffron,† held in solution by potash. With this view, when silks are washed, drained, and put on the rods, lime juice is poured into the bath, till it acquire a cherry color. It is then well stirred, and the silk repeatedly worked in it, until it has acquired a sufficient color.

To produce a lively, full poppy, the silk is wrung on coming out of the first bath, which it exhausts, and is then put into a second.

Five or six baths are requisite to impart to it a flame color. The poppy color is heightened by putting the silk through tepid water, acidulated with lime juice. A ground of annotto, three or four shades paler than aurora, is requisite for silks, before exposing them to the coloring principle of the carthamus plant.

The poppy color communicated by this last die, may be successfully imitated by the employment of Brazil wood.

The color thus produced is termed false poppy, to distinguish it from the true. To the silk is given a good ground of annotto, by boiling it with this die; after which it is washed, refreshed, passed through alum, and then worked in a bath of Brazil wood, to which a small portion of soap water has been added.‡

Black.

The following directions are given by a late author to die silk black,§ and refer to raw silk (*soie crue*) which has been reeled off dry.

The silk being cleansed, is to be bleached by being sulphured, or rather to be steeped in water charged with sulphureous acid,‖ then washed, and passed through water in which a small quantity of soap has been dissolved; then take three-fourths of the weight of silk, of gallnuts, make a strong decoction of them, and boil the silk therein for a short time: let it remain in the vat for thirty-six hours, then wash and wring it. The silk is so saturated with tannin, that 100 lbs. of silk, thus galled, will weigh 125lbs. Put in the bath copperas and gum, according to the quantity to be died, heat it, dip the silk therein, and, when deeply black, put it in a trough of cold water, in which it is to

* Extract from a paper by C. Baumach, Annales de Chimie, No. 137.
† Carthamus tinctorius.
‡ Chaptal, p. 485.
§ Manuel Complét du Teinturier, par M. Riffault, p. 95. Paris, 1825.
‖ The strength of the acid impregnation is not mentioned

be turned on a cylinder; then pass it through cold soap suds. As the price of Aleppo galls is high, white galls are often used, in the proportion of eight or ten parts of nuts to two parts of Aleppo galls. Diers have a caldron on purpose for black, and when the dying composition is exhausted, they renew it by what they called a brevet, (refresher.) When the deposite is considerable, it is taken out, and iron filings added to the liquid. The dying of the silk is finished by heating the caldron containing the die, and stirring it, from time to time, to prevent the sediment from heating too much.

The liquor must not boil; add more or less gum and iron solution; and, when the gum is dissolved, and the liquid nearly boils, it is left for one hour; the silk, divided into three portions, is then immersed, each portion in succession. The silk is lightly wrung three times, and aired each time. The great point of this operation is, to press out the liquor with which the silk is impregnated; and, when it is drained to fill it again therewith; and, above all, to expose it to the air, which deepens the color. After each portion of silk has been wrung three times, the vat is to be heated, and more gum and copperas added, as at first. The reheating of the vat is called giving *a fire*. Two fires are commonly given for a light black, and three for a deep die; and sometimes the silk is left in the vat, after the last fire, for twelve hours. Commonly, thirty kilogrammes* of silk are died in one operation.

This is technically called *a heat*. If half that quantity is died, only one fire is required for a light black. The dying being finished, the silk is rinsed on the rods according to art.

When the silk is died, it must be softened, by immersing it for a quarter of an hour in a solution of soap in water, in the proportion of from two to three pounds of soap to one hundred of silk. The quantity of water is not mentioned. It is afterwards wrung and dried.

Chaptal says: "A very full, clear, permanent black, has been obtained by the employment of a solution of iron immediately after a strong galling; the stuff is then immersed in a decoction of logwood, and next into this decoction conjoined with a solution of iron and verdigris: and this process is to be repeated till the black be very beautiful. With this view, 110 lbs. 5 oz. 10 dr. of silk, 44 lbs. 2 oz. 4 dr. of gall-nuts. 66 lbs. 3 oz. 6 dr. of copperas, calcined to redness, the same quantity of logwood, and 11 lbs. 9 dr. of verdigris, were employed.

The silk is to be first wrung out of the galls, allowed to dry, and then strongly shaken by the hands, in order to ventilate, and detach from it any adhering galls.

The same process of rubbing, shaking, &c. is to be employed in respect to the logwood bath; and the silk is to be carefully washed after each immersion in the solution of copperas. In the last logwood bath is to be dissolved 2 oz. 15 dr. of gum arabic, to 1 lb. 4 oz. 4 dr. of silk; the black is softened by passing the died silk through soap and water.

It has been observed, that, by combining vegetable astringents with the gall-nuts, a softer and more agreeable color was produced. Oak

* A kilogramme is 2 lbs. 3 oz. 5 drachms, avoirdupois.

bark, a species of agaric, pomegranate bark, &c. may be employed for this purpose.

The process by Vitalis.

I commence by boiling the silk in the ordinary way, with 20 lbs. of soap to 100 lbs. of silk, and, after it is well washed, and freed from the soap, it is dried. The skeins are then immersed in a decoction of galls in sort, in the proportion of two ounces to a pound of silk. The gall bath must be moderately warm. The hanks* are put on the rods, and lightly pressed, in order that the gall-liquor may penetrate them, and ensure a uniform color. They are then put in the bath, which must be kept warm during fifteen or eighteen hours; after this, they are to be taken out and dried, and then put in a warm bath of pyrolignate of iron, of the strength of five degrees, as marked on the areometer of Baumé, and dipped for some time; then immersed, and the heat of the bath increased, during five or six hours: observing to take them out and air them from time to time. After being taken from the iron bath, the silk is wrung and dried in the air, or under a shed in moist weather. It then receives two beetlings, and is subjected to a new galling, made with the remains of the former gall-liquor, and an ounce and a half of galls to the pound of silk: then taken out, wrung and dried. This second galling is followed by a new bath, made warm, of the pyrolignate of iron, of four degrees of strength, with the precautions before noted. The silk is again taken out, wrung, and dried, two more beetlings and a third galling given to it, the bath for which must have one ounce and a half of new galls to a pound of silk, and the former procedure renewed. It must then have another bath of pyrolignate of iron, of three degrees of strength, and be dried and washed. For a deep black, a fourth galling with one ounce of galls to a pound of silk, followed by a fourth bath of iron pyrolignate, of three degrees of strength, will be requisite. Then dry and wash carefully. The gum prescribed in the process of Angles,† gives a brilliancy which is highly prized by the trade. I supply its place, after the silk has been died and worked, by a light bath of warm soap and water, into which it is plunged for some time; after which it is to be washed and dried for the last time. Finally, my method does not exclude the employment of gum, which may be dissolved in the bath of the iron pyrolignate. Even where the process of M. Angles, or any similar one, is followed, advantage may be taken of the substitution I propose, of the pyrolignate for the copperas. A greater intensity and solidity of color will thereby be obtained, and the silk will suffer less.

* A hank weighs four or five ounces.

† See Cooper on Dying, for the process, p. 247.

TRANSLATION

FROM

A GERMAN TREATISE ON DYING SILK,

BY GEORGE WILLIAM HELTERHOFF:

PUBLISHED AT ERFURT,

1809.

Having discovered, after a diligent and patient comparison of several recent French works on dying, with that of Homassel, which was translated and published by Dr. Cooper, several years since, that they contained little more than the receipts of this author, the writer was induced to search for a German work on dying, in the hope of procuring original receipts. The work by Helterhoff was loaned and recommended to him by a German manufacturer of silk fringe, &c.; and the following articles pointed out, as worthy of insertion. They were accordingly translated; and, it is hoped, will be found useful.

EXTRACTS FROM A GERMAN TREATISE ON DYING SILK.

A handsome Yellow.

[Note—The following receipts are proportioned to 10 lb. of silk previously boiled.]

Take $1\frac{1}{4}$ lbs. of alum,
20 lbs. of common Lady's (St. Mary's) thistle,*
$\frac{1}{2}$ lb. of woad ashes.

Dissolve the alum in a kettle containing ten buckets of water, pour the solution into a vat, fix your silk upon rods,† and in the usual way, steep it in the solution, work it well therein for an hour, take it out, wring it, and lay it aside wet, for further use.

Put ten buckets of water in a kettle, add the St. Mary's thistle, and boil it well for a quarter of an hour; run the decoction through a sieve into a tub, to separate the coarse from it; let it cool, until you will be able to bear your hands in it; steep the silk in the liquor, work it well therein for half an hour, then take it out, wring it, and lay it aside, in its wet state, for further use.

The vessels in which you dress the silk with alum, must be kept, during the process of working it, to within a few inches of the top: and, should there be occasion to fill up, or to increase the quantity of liquor with water, care must be taken not to make it too cool, but to preserve, at all times, a degree of heat in which the hand can be barely held. While this is doing, the St. Mary's thistle must be put into the kettle a second time, with fresh water, and be boiled again. Then take out the silk, dip out some of the liquor, in which you had previously worked the silk, and add as much of the liquor of the second boiling to it as was taken therefrom, so that the first quantity will be preserved. The liquor must now, as well as each time before you steep the silk in it, be stirred well; then steep the silk in the liquor again, and work it well therein for half an hour.

The liquor may, in this latter process, be made a little hotter than it was in the first; but be cautious not to make it too hot, as the silk would be considerably injured thereby.

* This ingredient, which has not, as yet, been applied in this work, to the dying of yellow colors, is found growing spontaneously in an uncultivated state; but the cultivated is more esteemed. It flourishes best in a sandy soil, and must be cut as soon as it is of proper ripeness, which may be known by its having attained a handsome yellow color. [It is the *Carduus Mariæ.*—Editor.]

† This is to be understood as a general rule before steeping: the direction to attend it, will not, therefore, be repeated.

During this second process woad ashes* are to be dissolved in a kettle into which you have poured some of the liquor of the second coloring, boiling hot: stir the liquor and woad ashes well, and then let it settle: pour some of the clear part of the solution into the yellow liquor, after having first taken out the silk; stir the whole of it well, steep the silk in it again, and work it well therein during fifteen minutes. At the expiration of this time, or sooner, as you may deem it necessary, take out a small quantity of the silk, wring it, and examine whether it has retained the required color; should this not be the case, a small quantity of the solution of woad ashes must be added to the liquor, the silk steeped in it again, and well worked in the same, until the required color be obtained.

Note.—Should it be desired to heighten this color to a deep colored gold tint, add to the solution of woad ashes a quantity of annotto, in proportion to the degree of color desired.

The dying of light colored yellows is generally attended with many difficulties, as they will often be subject to changes in drying; and sometimes they will turn to a darker tint than they had while the silk was yet in a wet state: this is caused, principally, by too strong a dressing in alum. It is, therefore, best to give them a weak dressing in alum by themselves, or separate from those silks which are intended for other colors; and this may then be regulated, according to the degree of the color desired.

A Citron Yellow.

Take $1\frac{1}{4}$ lbs. of alum,
8 lbs. of safflower,
$\frac{1}{4}$ lb. of alum.

Dissolve the alum in a kettle containing ten buckets of water; then pour the solution into a vat, steep the silk in it, work it well therein for half an hour, wring it, lay it by in its wet state, for further use, and throw away the solution of alum as useless. Put again ten buckets of fresh water in the kettle, add eight pounds of safflower, and the quarter of a pound of alum; boil for half an hour, run the decoction through a sieve into a vat, steep the silk in the liquor, work it well therein a quarter of an hour, wring and dry it, fix it on the wringing post, wring and beat it well.

With the rest of the above liquor, a pale yellow may yet be died.

A Citron Yellow, which may be heightened to a handsome gold tint.

Take $1\frac{1}{4}$ lbs. of alum,
14 lbs. of safflower,
$\frac{1}{4}$ lb. of alum.

Put ten buckets of water in a kettle, add one and a quarter pounds of alum, dissolve it therein, pour the solution into a vat, and work the silk in the solution for about half an hour, wring it, and lay it by in its wet state, for further use.

* The woad ashes are chosen for this purpose, on account of possessing the quality, better than any other, of dissolving the coloring matter of the Lady's or St. Mary's thistle, and of incorporating it with the silk.

Pour ten buckets of fresh water into the kettle, add seven pounds of safflower, and boil it half an hour, pour the liquor through a sieve into a vat, and work it well therein for the space of fifteen minutes; then wring and dry it. The yellow liquor is now to be poured back into the kettle, the remaining seven pounds of the safflower to be put into it, together with a quarter of a pound of alum, and the whole to be boiled half an hour; then pour the liquor through a sieve into a vat, work the silk well in the liquor for half an hour, wring and dry it, and then beat it well. By the above process, a handsome citron yellow will be obtained.

A Citron Yellow, in a different way.

Take 1¼ lbs. of alum,
7 lbs. French berries.

Put the alum into a kettle, with eight buckets of water; when dissolved, pour it into a vat, immerse the silk in the solution, work it well therein for half an hour, take it out, and lay it aside for further use in its wet state, and throw away the solution. Then boil ten buckets of fresh water, put into it the French berries, boil for three quarters of an hour,* pour it through a sieve into a vat, and immerse the silk in the liquor, work it well therein for half a hour, wring and fix it on the wringing post in the usual manner.

To make this color deeper or brighter, take more or less than the above quantity of the French berries.

If the liquor, after this process, still retain some of its yellow properties, it may be used to color ten pounds of silk, previously prepared in a solution of alum, to a pale yellow, or to lay at least the ground for a handsome gold tint.

A Citron Yellow, in another manner.

Take 2 lbs. of alum,
6 lbs. quercitron bark, ground.

Put the alum in a kettle, with ten buckets of fresh water, dissolve it therein, and pour the solution into a vat, immerse the silk in it, and work it well therein for two hours; wring it, lay it aside wet for further use, and throw away your solution of alum as useless. Then pour into a kettle ten buckets of fresh water, and put the ground quercitron into it; boil this one hour, take it out, run the decoction through a sieve into a pail, immerse the silk in the liquor, and work it well one hour in the same; after which, it is to be taken out, wrung and dried; fix it on the wringing post, wring it again, &c. when it will have acquired a beautiful citron yellow.

The remaining yellow liquor may be used for other purposes, and may therefore be preserved. I will now give the necessary directions

* A small quantity of alum may be added to the French berries, and boiled with them whereby the color of the liquor is much improved.

for coloring a handsome pale yellow, with the above remains of the yellow liquor.

A Pale Yellow.

Take 2 lbs. of alum.

Prepare the silk with alum, as directed in the foregoing receipt, and lay it away for further use. Then warm the liquor, which has been used in the coloring of the foregoing operation, put it into a vat, immerse the silk in the liquor, and work it well therein for the space of half an hour. This being done, take it out, wring it, fix it on the wringing post, wring and beat it well, which will give it a gloss.

It is not necessary that the silk should be rinsed in yellow coloring.

SEVERAL DIRECTIONS FOR DYING WITH QUERCITRON BARK.

A Citron Yellow.

Take 3 lbs. of alum, and
1 lb. 3 ounces of quercitron bark.

Dissolve the alum in a kettle, with ten buckets of water, pour the solution into a vat, immerse the silk in the solution, and work it well therein a little longer than usual; take it out, wring and rinse it, and lay it by for further use, in its wet state; put ten buckets of fresh water in a kettle, warm it, put the quercitron in a bag, and boil it until the strength is extracted. Then immerse the silk in the liquor, and work it well therein a quarter of an hour, which will produce a handsome lively citron yellow.

A high-colored Yellow.

This color may be heightened to its utmost extent of yellow, by adding a few half ounces of soda, more or less, according to the deep or bright shades of color desired, to the above yellow liquor; but this must not be done until the silk has been completely saturated with the yellow liquor of quercitron.

Orange Color.

Orange color is obtained by adding to the liquor at the same time with the soda, a proportional quantity of annotto, and by working it in this liquor until the desired color has been obtained.

Pale Yellow, or Straw Color.

Take less alum and quercitron, and dispense altogether with the soda and annotto.

Buff.

To produce the many different shades of this color, proceed with the quercitron in the same manner as directed in the dying of the same colors with turmeric and weld, (dier's weed.) But you must bear in mind that one pound of the quercitron will produce as much as ten pounds of either the turmeric or weld.

A very lively glossy Yellow.

If you desire to increase the above yellow to its most lively and glossy hue, take, instead of the alum, a solution of tin, dissolved in a mixture of three parts of the spirits of salt, and one part of aquafortis. This solution must be mixed with twenty times its own quantity of water, and the silk is to be prepared in a solution of alum in the usual way; but it is not necessary to rinse it, and may be colored immediately. The solution of tin may be preserved for other purposes.

A Turkish Blue.

Take 2½ ounces of cochineal,
10 do of aquafortis,
1½ do of English tin, and
¼ lb. of alum.

The silk must first be colored in a keep, to a medium blue. This being done, take a kettle containing ten buckets of water, put into it two and a half ounces of cochineal, and boil it well for the space of ten minutes.

During the above process, dissolve the tin in the aquafortis, according to art; pour the solution, together with a quarter of a pound of alum, into the above-mentioned kettle, with ten buckets of water. Stir this liquor well, and immerse the silk in it, and work it well therein for about three-quarters of an hour, during which time it must be kept at a steady, slow, continued boil; then take it out, rinse, wring it, fix it on the wringing post, wring and beat it well, which will restore it to its natural gloss again.

Note.—If you do not like to make use of the aquafortis in the above process, you may substitute a quarter of a pound of cream of tartar, and increase the quantity of alum from a quarter to a half pound.

A real Pink.

Take 15 lbs. of safflower,
15 quarts of strong vinegar,
⅜ of an ounce of oil of vitriol,
1 lb. 14 oz. potash, and
4 ounces of cream of tartar.

Put the 15 lbs. of safflower in a bag, tie it tight, immerse it forty-eight hours in running water; take it out, during this time, every six

hours; tread it well, until all the yellow matter has been worked out; examine it at the expiration of the above time, to see whether it has lost all its yellow coloring matter; if it has not, immerse it a few hours more into the water; this being done, take it out, put it into a vat, and pour six buckets of river water upon it.

This being done, dissolve one pound fourteen ounces of potash in water, and pour the clear part of this liquor on the safflower in the tub; mix it well, and set it by, in a cool place, for six hours. At the expiration of this time, take out the safflower with its liquor, run it through a sieve into a vat, pour half a bucket of water upon it, and press it out, in order to extract all the coloring matter therefrom; pour fifteen quarts of vinegar, and three-eighths of an ounce of oil of vitriol into the liquor; then take the ten pounds of silk, fix it upon rods, put it into this safflower liquor, and work it well therein, for the space of four hours; then take it out, rinse it in running water, wring it well, and lay it aside for further use, in its wet state.

Lastly. Dissolve four ounces of cream of tartar in river water, and pour the clear part of this solution into a tub, with eight buckets of river water; immerse the silk, which has before been colored to a light red, in this solution, and work it well therein for a quarter of an hour; take it out, wring it and dry it, and you will have a handsome pink.

Note.—For a pink of a higher color, take an additional quantity of safflower; and for a lighter, take less than the above prescribed quantity. It will likewise be of benefit to add a small quantity of vinegar. Lemon juice, however, is unnecessary.*

A high-colored Crimson.

Take $1\frac{1}{4}$ lb. of cochineal,
1 lb. of galls,
4 ounces of cream of tartar, and
$2\frac{1}{2}$ lbs. of Roman alum.

Dissolve two and a half pounds of Roman alum in a kettle, with ten buckets of water; pour the clear part of this solution into a vat, immerse the silk in it, and work it well therein for the space of four hours; then take it out, and rinse it in running water, wring it, and lay it by for further use, in its wet state; then put in a kettle containing eight buckets of boiling water, the following articles:

One and a quarter pounds of finely powdered cochineal, one pound of finely powdered gall-nuts, and four ounces of cream of tartar. Let the whole boil slowly, for the space of fifteen minutes; cool it with two buckets of water, work the silk well in the liquor, which must be kept in a continual boil, for the space of one hour and a half; then take it out, rinse it, wring it, and let it dry, when the dying will be completed.

* Dr. Cooper says that lemon juice is essential to bring out the pink color of safflower, by neutralizing the alkaline liquor in which the plant is steeped.
[*Cooper on Dying.*

For a cheaper color than the foregoing, reduce the quantity of cochineal, from one and a quarter pound to ten ounces, and substitute, for the remainder, three pounds of persio;* and proceed with these materials, in the same manner as above directed. This color will differ from that of the first described process, in no other respect than that it receives somewhat more of a blueish cast.

A handsome Crimson.

Take 3 lbs. of Roman alum,
½ ounce of argol,†
½ lb. of East India galls,
25 ounces of cochineal.

Heat eight buckets of rain water in a kettle, lukewarm; dissolve three pounds of Roman alum therein, take out the solution, and put it into a vat, immerse the silk in the solution, and work it well therein for the space of eight hours.

Take it out at the expiration of this time, wring it lightly, and lay it by for further use, in its wet state.

To complete this color, heat eight buckets of well or spring water, until it begins to boil, put into it the following articles: half an ounce of argol, and half a pound of finely pounded East India galls; let the whole of these articles boil well for about ten minutes, and run the liquor through a sieve, into a pail; then pour the liquor back into the kettle, and put into it twenty-five ounces of pulverized cochineal: let it boil ten minutes more, cool the liquor with half a bucket of water; immerse the silk in this liquor, and work it well therein for the space of two hours, during which time the liquor must be kept at a continual boil. This being done, take it out, rinse it well, wring it strongly, and dry it.

Then take a kettle with ten buckets of spring or well water, and heat it so that you may bear your hand in it; work the silk well in this water for half an hour, then take it out, wring and dry it. By this process we obtain a very handsome crimson.

NOTE.—An ounce, instead of half an ounce of argol may be used; but this is left entirely to the judgment of the dier, whether found necessary or not. If this crimson be desired less of a red, and not so handsome, proceed with the cochineal; and the quantity prescribed above may be reduced to eighteen ounces. The process must be, in this case, the same as above directed.

A deep Red.

Take 1 lb. of fine galls,
2½ lbs. of alum,
½ lb. of composition, and
5 lbs. of madder.

* The cudbear of the English diers.—EDITOR.

† Red argol is the tartar from red wine. White argol is the impure deposite from white wines. Cream of tartar is pure argol.—EDITOR.

Put into a kettle eight buckets of water, and one pound of fine galls; let it boil about fifteen minutes, or until the strength is extracted; run it through a sieve into a vat, steep the silk in this decoction, and work it well therein for about two hours: after which, take it out, rinse, and dry it. Then put into a kettle eight buckets of water, with two and a half pounds of alum, and half a pound of the composition: let these be properly united with the water; pour the liquor into a vat, steep the silk in the solution, and work it well therein for the space of four hours: take it out, rinse, and lay it by, in its wet state, for further use.

Lastly. To complete this color, put in a kettle ten buckets of water, add five pounds of madder, and work the silk well in this liquor, until it begins to boil; then take it out, rinse, and dry it.

A real Brown.

Take 6 ounces of annotto,
1 lb. of potash,
3 lbs. of alum,
5 oz. of fine galls,
$\frac{1}{4}$ oz. of cream of tartar,
2 oz. of turmeric, and
10 oz. of cochineal.

Boil a kettle with ten buckets of water, powder six ounces of annotto, and put it together with a pound of potash, into the kettle; boil for a quarter of an hour, pour the liquor through a sieve into a tub, immerse the silk, and work it well in the liquor for the space of two hours; then take it out, rinse, wring, and dry it. After this, pour eight buckets of fresh water into a kettle, dissolve three pounds of alum therein; then put the solution in a vat, steep the dried yellow silk, and work it well therein for the space of three hours; then take it out, wring, and lay it by, wet, for further use.

Boil a kettle with eight buckets of water, put into it ten ounces of cochineal, and let it boil for about ten minutes; then cool the liquor with a bucket of water, and put into it a quarter of a pound of cream of tartar, and two ounces of turmeric, and stir the whole well; then steep the silk previously alumed, in the liquor, work it well therein for the space of two hours; during which time it must be kept at a continual boil. Then take it out, rinse in running water, wring, and lay it by, in its wet state, for further use.

This being done, die it in a keep, [die tub] light or dark, as your taste may be, or according to the pattern which is laid before you.

If you do not wish to make use of the keep, or, as is often the case in small dying establishments, should you not possess one, you may apply the indigo coloring.

You may likewise color it in the liquor of logwood, which will render it equally handsome, but not of so lasting a color.

A real Crimson, in another way.

Take 2½ lbs. of Roman alum,
2 lbs. of fine galls,
1 lb. 4 oz. of cochineal,
¼ lb. of argol, and
8 oz. of spirits of ammonia.

Take a kettle with eight buckets of water, put into it two pounds of fine galls, boil for a quarter of an hour; run the liquor through a sieve into a pail, steep the silk in the liquor, and work it well therein for the space of four hours; take it out, rinse, wring and dry it.

After this, take a kettle with eight buckets of water, and dissolve in it two pounds of Roman alum; pour it into a vat, steep the silk in the solution of alum, and work it well for the space of four hours in the same; then take it out, wring it, and lay it by, in a wet state, for further use.

To complete the color, pour six buckets of water in a kettle; add one pound and four ounces of fine cochineal, a quarter of a pound of argol, and eight ounces of spirits of ammonia; let all boil well together for about ten minutes, then cool the liquor with two buckets of water: work the silk in it for two hours; during which time it must be kept boiling continually: then take it out, suspend it on the rods over a vat, pour the liquor from the kettle into it, and continue to work the silk in the liquor until it has become cool; take it out, rinse, and dry it in the shade.

By following the above directions you will obtain a very handsome crimson.

To turn this expensive cochineal liquor to all possible advantage, (for it will still have retained some good coloring matter,) pour the above used alum liquor into it, and heat it again; which will enable you to color many lighter shades, from the rich peach blossom down to the lightest lilac color. Having used it for this purpose, you may take more or less of silk of a yellow ground, and color it in it, which will receive a reddish yellow from it.

A handsome Red.

Take 8 oz. of annotto,
1½ lbs. of potash,
2½ lbs. of alum,
6 lbs. of Brazil wood,
5 buckets of sharp vinegar, and
6 ounces of composition, p. 191, 192.

Boil a kettle with eight buckets of water, and put in it eight ounces of annotto, powdered as fine as possible; add one pound and a half of potash; let the whole boil well for a quarter of an hour, and pour the liquor through a sieve into a vat. Steep the silk in this liquor, and work it well for two hours, after which take it out, rinse, wring, and dry it.

Then dissolve one pound and a half of alum in a kettle with eight buckets of water; pour this solution into a vat, fix your silk upon rods, and work it well therein for two hours; then take it out, wring and dry it.

When the silk is completely dry, steep it in warm water, until it has become properly soaked. Then take it out, wring, and lay it by, wet, for further use.

This being done, pour into a vat five buckets of sharp vinegar, and six pounds of Brazil wood, and let it stand for the space of forty-eight hours: then take the liquor out of the vat, and pour it into a kettle; let it boil for the space of ten minutes; then pour it through a sieve, into a vat, and throw the parts remaining in the sieve into the kettle again; pour three buckets of water upon it, let it boil well for a quarter of an hour, and add the liquor thereof to the other Brazil wood liquor in the vat.

Pour six ounces of the composition into this liquor of Brazil wood, and stir it well; steep the silk previously soaked in warm water, in the liquor, and work it well therein for the space of two hours. Examine, at the expiration of this time, whether the liquor still contains any coloring matter; if so, take it out, pour it into the kettle again, work the silk another time therein, during which it must be kept moderately warm; then take it out, rinse it in running water, wring, and hang it up to dry. By observing the whole of the above process you will obtain a very handsome red. By using eight buckets of vinegar instead of five, the color will be considerably improved; and by dispensing with the composition altogether, the color will become darker.

Lastly: If you desire to have this color of a darker and fiery hue, add two pounds of Brazil wood, and one pound of composition, to the above quantity, and proceed in the same way as above directed.

TO COLOR SILK CITRON YELLOW WITH QUERCITRON.

Take $2\frac{1}{2}$ lbs. of alum,
$\frac{1}{4}$ lb. of sugar of lead,*
2 oz. of chalk, and
3 lbs. of quercitron.

Take a kettle with eight buckets of water, dissolve in it two and a half pounds of alum; pour it into a vat, and let it become cold; add to it a quarter of a pound of sugar of lead, and stir it well, then put into it two ounces of chalk, stir it well, and continue the stirring, at proper intervals, for the space of twelve hours, and set it by to settle. Pour off the liquor into a vat, but be careful not to disturb the sediment at the bottom: steep the silk in the liquor, and work it well therein for the space of six hours; then take it out, wring and lay it by, wet, for further use.

After this, take a kettle with eight buckets of water, put into it three pounds of quercitron bark, and let it boil for the space of three

* Acetate of lead.

quarters of an hour; pour it through a sieve into a vat, steep the silk, which has been saturated in the foregoing liquor, composed of alum, sugar of lead and chalk, in the quercitron liquor, and work it well for the space of an hour; then take it out, rinse, wring, and dry it.

If you desire a higher colored citron yellow than the above, add another pound of quercitron to the above quantity, and proceed in the following manner:

Saturate the silk, as above directed, in a liquor of alum, sugar of lead and chalk; then take a kettle with eight buckets of water, boil two pounds of quercitron therein, for the space of three quarters of an hour, and pour the liquor through a sieve into a vat; steep the silk, and work it well therein for the space of two hours; after which, take it out, wring and dry it. This will have given the silk the best of grounds for a good yellow color. After this, take another kettle with eight buckets of water, put into it two more pounds of quercitron bark, and boil it for the space of three quarters of an hour: then pour it through a sieve into a vat, and work the previously colored and dried silk in the same, for the space of two hours; then take it out, rinse, wring, and dry it.

A high-colored and deep Citron Yellow.

Take $1\frac{1}{2}$ lb. alum,
3 oz. of sugar of lead,
$1\frac{1}{2}$ oz. of chalk, and
8 lbs. of French berries.

Dissolve in a kettle which contains eight buckets of water, one pound and a half of alum, pour the solution into a vat, or, which is better, into a cask,* and let it cool. Put into it three ounces of sugar of lead, stir it well with a rake, add one and an half ounces of finely powdered chalk, and stir the whole well again; and continue the stirring every hour, for twelve hours. But, after the last stirring, the rake must be taken out of it, to prevent the sediment from being disturbed, and then let it stand twelve hours. At the expiration of this time, draw off the liquor; but be careful not to disturb the sediment, which would otherwise create stains that are difficult to remove; pour the liquor, thus drawn off, into a vat, work the silk well in it for the space of four hours; after which, take it out, wring and dry it; then moisten it with warm water, rinse it in running water, wring it, and lay it by wet, for further use; then take a kettle with eight buckets of water, and at the same time bruise eight pounds of French berries in a mortar; put them into the kettle, and let them boil for half an hour; then take out the liquor, and run it through a sieve into a vat. Steep the silk in the liquor, and work it well therein for half an hour; take it out, wring and dry it; this will produce a handsome citron yellow.

* This cask must have a spicket, about a hand's breadth from the bottom, for the purpose of drawing off the liquor.

With the above used alum solution and French berry liquor, you may, without any other addition, color a brighter citron yellow. The same solution may likewise be applied, with turmeric or weld, in dying a yellow.

A Nankeen.

Take 2 lbs. of fine galls,
1½ oz. annotto,
4 oz. of potash, and
½ lb. of soap.

Put one pound of finely powdered galls in a kettle of eight buckets of water, and boil it about ten minutes, then take out the liquor, and run it through a sieve into a vat.

While thus employed, let half a pound of soap be dissolved in a bucket of warm water, and pour the solution into the liquor of the galls.

Then put into a crock of water one ounce of annotto and four ounces of potash; boil for half an hour, add the one half of it to the liquor of the galls in the vat, and stir the whole well; steep the silk in the liquor, and work it well therein for a quarter of an hour. Examine the silk, and should it not have the necessary redness, add as much of the annotto liquor to it as you may deem necessary, to give the color the desired tint. Then put the silk in again, and work it well for a quarter of an hour; take it out, rinse and dry it.

The nankeen-colored silk must not remain long without being rinsed, as this would create stains in it.

A handsome Turkish Blue.

Take 1¼ lb. of alum,
2½ oz. of cochineal,
½ lb. of composition,
¾ of an ounce of indigo, and
3 oz. of oil of vitriol.

The silk, after being boiled in soap and water, must be rinsed in running water, and then wrung and well beaten. This being done, it must be colored to a handsome light blue, in a cold or warm keep; then rinse it in running water, wring and dry it.

As soon as the silk has become properly dry, it must be moistened in warm water, wrung and laid by, wet, for further use.

Dissolve in a kettle with eight buckets of water, one and a quarter pounds of alum, pour the solution into a vat, steep the silk in it, and work it well therein for the space of an hour; take it out, wring, and lay it aside, in its wet state, for further use.

Lastly: boil a kettle with eight buckets of water, and put into it two and a half ounces of cochineal: let it boil for about ten minutes; cool the liquor with a bucket of water, and add half a pound of the solu-

tion of tin, and three quarters of an ounce of indigo, which has been previously dissolved in three ounces of oil of vitriol, and stir the whole well. Immerse the silk colored blue in the cochineal liquor, work it well therein until the liquor begins to boil, let it boil another hour, during which time the silk must however be continually worked: it must then be taken out, rinsed, wrung, and dried.

If you desire this Turkish blue to incline more to a red, increase the quantity of the cochineal; if the contrary, take less.

A handsome Green.

Take 2 lbs. of alum, and
4 lbs. of quercitron bark.

Dissolve in a kettle, with eight buckets of water, two pounds of alum; then pour it into a tub, and set it by until wanted.

While engaged in preparing the above solution, the silk must be colored in a cold keep to a handsome light blue, and, after being rinsed in a stream, wring and steep it in the above-mentioned alum liquor; work it well therein for two hours, then take it out, wring, and lay it by, wet, for further use.

Lastly: put four pounds of quercitron bark in a kettle with eight buckets of water, boil it well for the space of three quarters of an hour, and pour the liquor through a sieve into a tub.

At the same time, and while this is doing, prepare an incorporation of indigo and oil of vitriol,* and pour the same into the quercitron liquor in the tub, and stir the whole well. Steep the silk in this compounded liquor, and work it well therein for the space of half an hour; then take it out, wring and dry it.

In case the silk has not attained as handsome a green as desired, add a small quantity of turmeric to the yellow liquor, which will assuredly have the desired effect.

At the same time I would recommend not to color the silk too dark in the cold keep, as it is very difficult to produce a handsome green on a ground which has been spoiled by keeping it in the dark. It is therefore more adviseable to have it of too light a color, as you may, in that case, easily regulate the color by adding more of the preparation of indigo to the yellow liquor, as circumstances may require.

Best Blue, (ultra Marine.)

The quantity of the necessary ingredients for this color, must be regulated according to the quantity of silk to be colored.

Take filings of copper, free from all alloy of other metals; it is best, therefore, to rasp or file them yourself, in order to obtain them pure. Put these into a glass vessel, pour spirits of salt, [muriatic acid] sufficient to cover them twice as deep as the space they occupy; let them stand for the space of twenty-four hours, or as long as necessary for the spirits of salt to attain a blue or deep green color.

Then pour off the clear part of the colored spirits of salt into an-

* The proportions are nine or ten parts of the strong acid, to one of indigo, at a temperature of 100° to 112° of Fahrenheit's thermometer.—EDITOR.

other glass vessel, add fresh spirits of salt to the copper filings, and continue this process until the whole of the copper filings have been dissolved, when nothing but the earthy and impure parts will remain.

Mix all these several blue or deep green colored solutions of copper, and add thereto as much spirits of ammonia as will be necessary to saturate the mixture.

Then moisten the silk in warm water; but be careful to do this in such a manner that all parts will be completely and equally soaked; then wring it, and steep it in the blue tincture prepared as above directed; work it therein until it has attained a handsome ultra-marine color: then take it out, wring it well, rinse in a stream, and dry it in the shade.

By minutely observing the above process, you will obtain a very handsome blue color, but which is not altogether lasting, as it will fade by being exposed to the sun, and turn to a greenish tint.

With the liquor which remains, you may color many other very agreeable blue colors; but you must add, at every coloring, a small quantity of spirits of ammonia to the liquor, as it would otherwise cause the color of the silk died therein, to receive more of a green, and less of a blue color, at every succeeding coloring.

A dark Blue.

Take 1½ ounces of indigo,
¾ lb. of oil of vitriol,
1¼ do. of alum,
4 do. of logwood,
¼ do. of alum.

The greatest attention and accuracy in the process of dying this color is necessary.

Before you proceed to the dying itself, prepare a solution of indigo in oil of vitriol. in the manner following: Powder very finely, and sift one and a half ounces of indigo, and put three quarters of a pound of oil of vitriol in a stone jar; add the pulverized indigo to it, stir the whole well with an earthen pipe stem, or some similar earthen article, and continue the stirring until the oil of vitriol ceases to ferment; the mixture having become quiet, set it by for the space of twenty-four hours; at the expiration of this time, a little water must be added, and the whole matter stirred again, by which it will receive, as it were, new life and vigor; after which, it must be set away undisturbed, until it is to be applied to the dying of the silk. After this, prepare a kettle with eight buckets of water, put into it one and a quarter pounds of alum, and dissolve it completely therein. This being done, pour the solution into a vat, steep the silk in the solution, and work it well therein for an hour; after which, take it out, wring, and lay it by, wet, for further use.

Put eight buckets of water in a kettle, pour the solution of indigo into it, and mix it well, work the silk well in this blue liquor for the space of half an hour, then take it out, rinse it in running water, wring and lay it by, wet, for further use. By this process, the silk will receive a handsome light blue color.

To deepen this blue, or to change it to a dark blue, proceed in the following manner: boil a kettle with sixteen buckets of water, add four pounds of logwood, and boil it well for about three quarters of an hour; then take out one half of the liquor, and run it through a sieve into a vat; let the other half or eight buckets of the same remain in the kettle for further use; put into the liquor in the vat, a quarter of a pound of alum, which has previously been dissolved in some vessel; stir the whole well, steep the light blue silk in it, and work it well in the liquor a quarter of an hour; then take it out, wring and keep it wet for further use, and throw out the liquor as useless.

Lastly: pour into another vat the remaining eight buckets of the logwood liquor left in the kettle, after having first run it through a sieve; steep the silk in the liquor, and work it well therein for the space of half an hour; then take it out, rinse it in running water, wring and dry it. By the above process, you will obtain a dark blue, in every respect equal to any of the blues which have been colored by means of the keep.

The above blue is likewise applicable to the dying of any other goods; and not alone in this respect is it of advantage, but it likewise saves you the trouble and expense of preparing a keep for dying a small quantity of silk to a dark blue; and if the risk of missing a keep, and the consequent loss thereof be taken into consideration, the above receipt is of considerable advantage to the dier as well as to the manufacturer; particularly as the smallest quantity may be colored equal to the coloring of a keep, by reducing the ingredients in proportion to the quantity of the silk which is to be died.

A handsome Violet Blue, after the manner of the foregoing.

Take 1 oz. of indigo,
$\frac{3}{4}$ lb. of oil of vitriol,
$\frac{1}{4}$ lb. of alum,
4 lbs. of logwood, and
1 lb. Guinea or red wood.

The indigo must be dissolved in oil of vitriol, as directed in the foregoing receipt, and kept ready for use.

Dissolve in a kettle, with eight buckets of water, a pound and one-quarter of alum; then pour the solution into a vat, and work the silk well therein for the space of one hour; after which time, take it out; wring, and keep it in its wet state, for further use.

Fill a vat with eight buckets of water, put the above-mentioned solution of indigo in it, stir the whole well, work the alum-dressed silk therein, for the space of half an hour; then take it out, rinse it in running water, wring it, and set it by, wet, for further use.

Lastly: take a kettle with eight buckets of water, put into it four pounds of logwood, and one pound of Guinea or red wood, and boil the whole well, for about three-quarters of an hour; then run the decoction through a sieve into a vat, steep the blue colored silk in it, and work it well in the same for the space of half an hour; after which take it out, rinse it in running water, wring and dry it.

Note.—I deem it necessary to add to the liquor of the logwood and red wood, a quarter of a pound of alum.

A deep Red.

Take 5 oz. of annotto,
1 lb. of potash,
$2\frac{1}{2}$ lbs. of alum, and
5 lbs. of madder.

Into a kettle with eight buckets of water, put five ounces of madder, which has previously been finely powdered, add thereto a pound of potash, boil it well for a quarter of an hour, run it through a sieve into a vat, steep the silk in it, and work it well therein for an hour; then take it out, rinse it, and let it dry; dissolve two and a half pounds of alum in a kettle, pour the solution into a vat, steep the silk in it, work it well therein for two hours, then take it out, wring and dry it.

Lastly: fill a kettle with eight buckets of water, add five pounds of madder, heat it, but do not let it boil; while this is doing, moisten the silk well in warm water, so as that all of it may be equally saturated with the water; take it out and wring it; then steep it in the above prepared lukewarm liquor of madder, work it well therein until it begins to boil; let it boil a quarter of an hour longer, during which time the silk must be worked continually; then take out, wring, and dry it. The above process will produce a very handsome red.

A Green.

Take $1\frac{1}{4}$ lbs. of alum,
1 lb. of potash, and
8 lbs. of turmeric.

The silk must be first died in a cold keep, to a handsome light blue; but caution must be used to lay the color equally throughout the whole of the silk, and that no stains remain in any part of it; rinse it in running water, wring it, and lay it by wet for further use.

Immerse the silk in warm water, in such a manner that it will be equally and uniformly saturated with the water; then wring it, and lay it aside in its wet state for further use.

After this, prepare a kettle with eight buckets of water, put into it one pound of potash, and one and a quarter pounds of turmeric, and let the whole boil well for about ten minutes; then pour the liquor through a sieve into a vat, steep the silk in the liquor, and work it well therein for the space of half an hour. At the expiration of this time, it must be taken out, wrung, and put by for further use, in its wet state.

Lastly: dissolve a kettle with eight buckets of fresh water, one and a quarter pounds of alum, pour the solution into a vat, and work the silk well therein for the space of a quarter of an hour, which will change it to a handsome green; then take it out, rinse, wring, and dry it in the shade.

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Fig. 1.

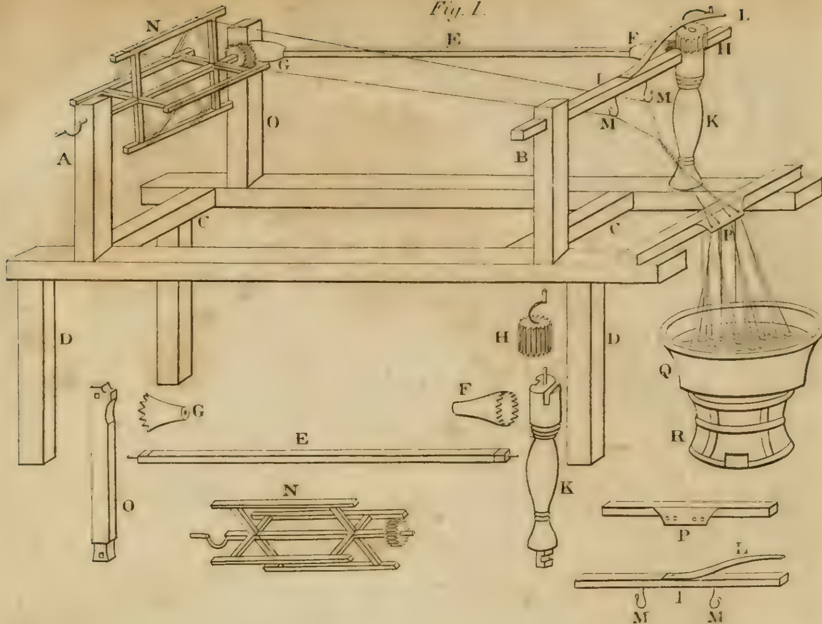


Fig. 2.

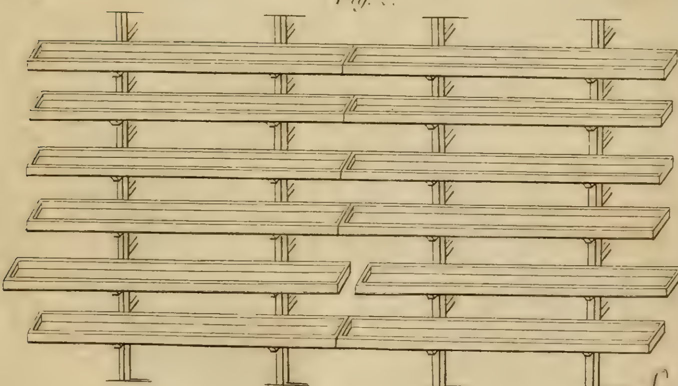
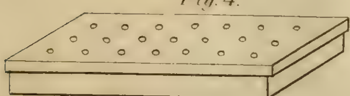


Fig. 7.

Fig. 4.



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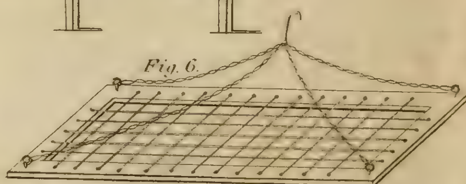

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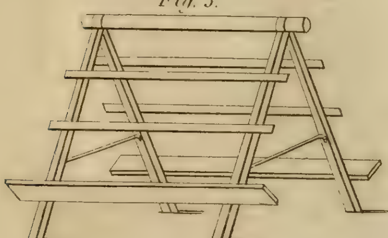
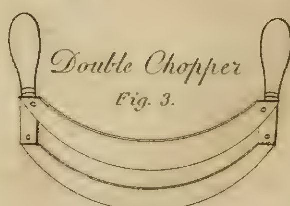




Double Chopper

Fig. 3.

Indigo Cradle.

Fig. 2.

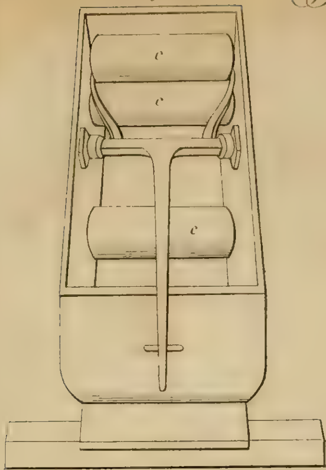
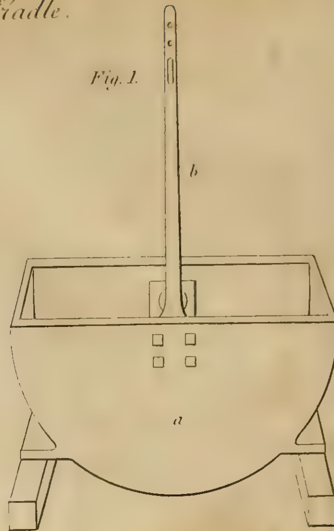


Fig. 1.



Rattan Slides for silk worms.

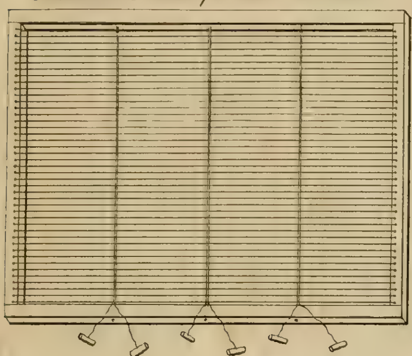
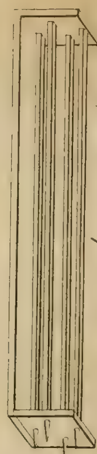


Fig. 3.

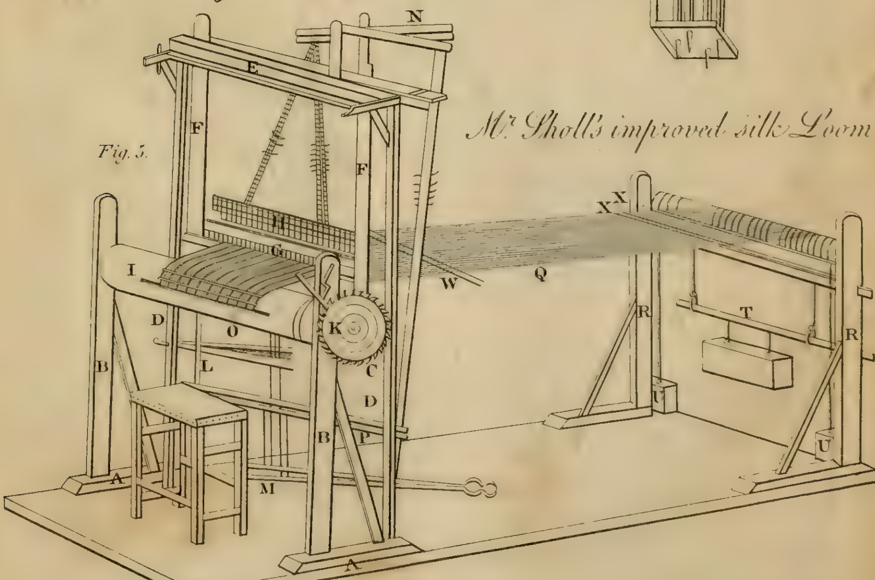
Fig. 4.



Cocoon frames.

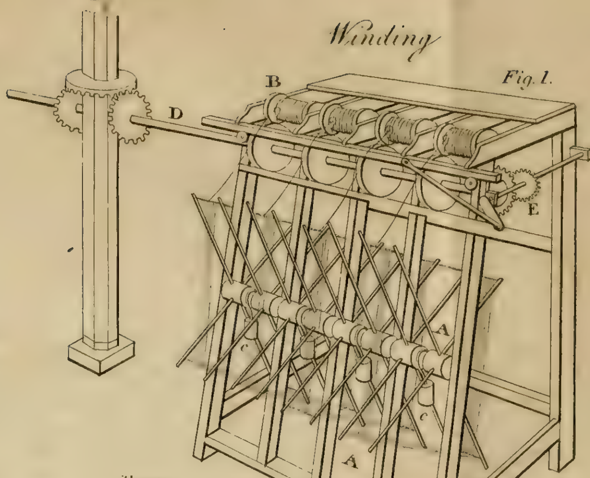
Mr. Sholl's improved silk Loom.

Fig. 5.



Winding

Fig. 1.



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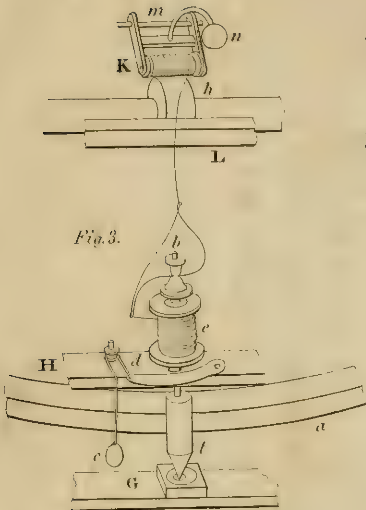

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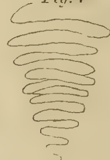
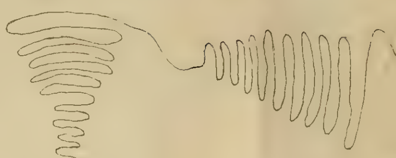
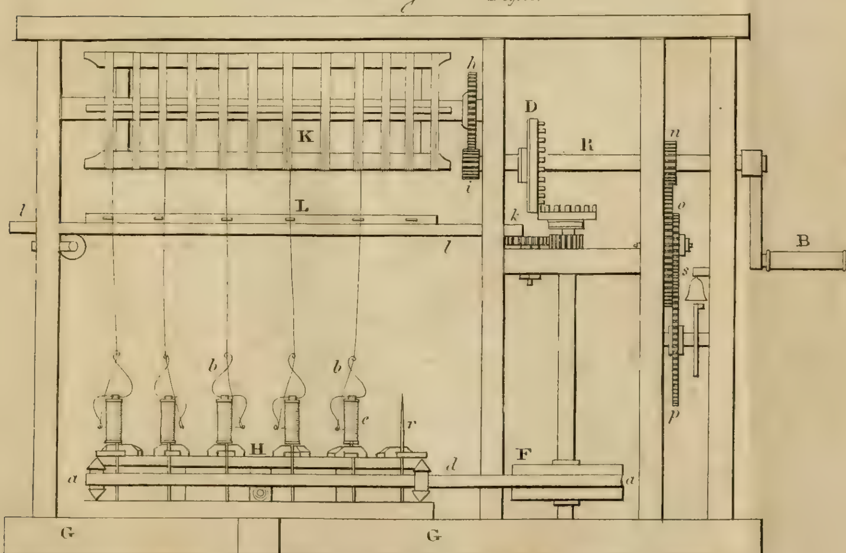


Fig. 5

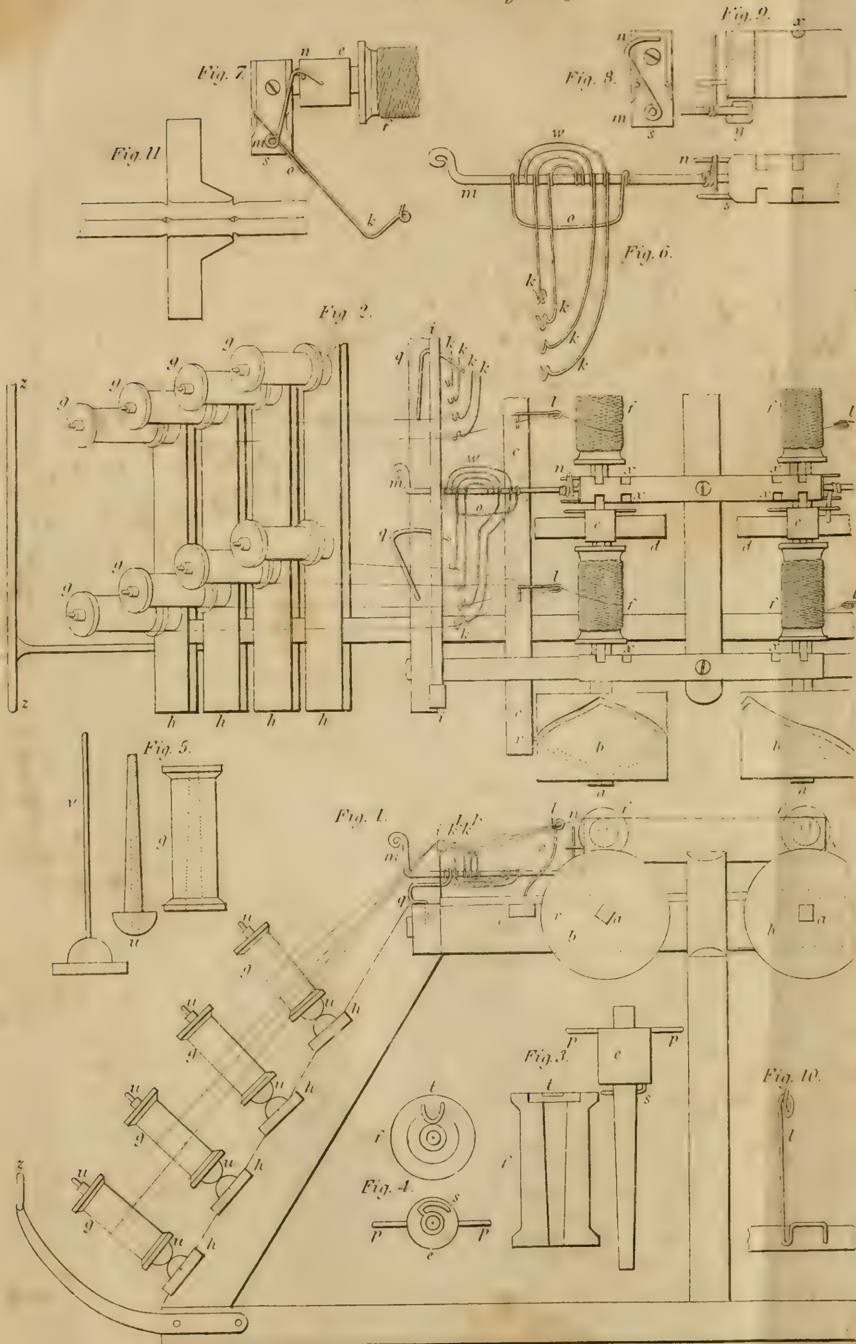


Throwsting

Fig. 2.



Shenton's Tramming Engine.



Silk Loom exhibiting Mr. Richards's improved Drawboy.